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## The Industrial Engineer.

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# EDITORIAL.

### The Munitioners' Interval.

The long-deferred holiday for our munition makers has come and gone. It has been a brief spell, in fact all too brief, since it has only allowed a taste of the joys which should form the basis of a really decent holiday. Fortunately, for the time of the year, the weather has been on its very best behaviour, and we have no doubt this will have contributed materially to the enjoyment of the short respite from the strenuous work of providing our Army and Navy with all its engineering requirements. Our men have stuck to their work well, notwithstanding the little flutters of a few ardent growlers on the Clyde and some other centres. We always believed they would make good when they were convinced of the urgent necessity for strict attention to the business of munition making. Only those who know what a steady, strenuous grind it has been all the time can appreciate the necessity for a few days' respite. May they soon be able to have a much longer spell.

### A Surprise for the Germans.

Nothing that has happened in this greatest of all wars has caused so much surprise to the Germans as the introduction of what are now known as the "Tanks." That they have been a great success is evident from Sir Douglas Haig's dispatches, and those of the Press correspondents who are allowed to pen the doings of our Army. An unconscious tribute to their successful operation is to be found in some sections of the German Press, which now declare the "Tanks" to be a German invention. We may be quite sure that if this were the case we should have had them in opposition to us long before now. However, we don't mind letting them have the credit of the invention even, so long as we can deliver the goods. As a matter of fact, and without belittling the meritorious and useful character of this engine of war, it is doubtful of it is of really recent invention. We are not acquainted with its general construction, so cannot say, but this much we know: that a search of our Patents Records would doubtless reveal many characteristics which are not in themselves new in the domain of caterpillar locomotion. Anyway, the "Tanks" are effective, and we hope there are plenty of them. They'll want to be geared up a bit when we get through a few more trenches, and get the Germans on the run.

### More British Ingenuity.

It is such a general British characteristic to be self-depreciatory—and in a large number of cases without any real warrant therefor—that we are sure we may be excused for indulging in a little appreciation of our own skill now and then. So it is with real satisfaction that we learn on the eve of going to press of the destruction of the fourth Zeppelin in as many weeks. Our mechanical defences against hostile aircraft are undoubtedly improving, both in the direction of better guns, range-finding appliances, and better aeroplanes. And we must not forget either the men who invent or those who so skilfully use them. We shall get "top dog" of the Zeppelins just as sure as we have done with under-water craft. We are not by any means at the end of our inventive tether. We are just refreshing our brains, and when they have got really nice and clean the Germans may look out for more squalls to make them squeal. We have not done ourselves justice in the past. Perhaps in some things we have been too tolerant and easy. We have now seen the reflection, and know where to trim up.

# THE GENERATION OF ELECTRICITY ON A SMALL SCALE OR BULK SUPPLY.

By H. S. Ellis (Borough Electrical Engineer, South Shields).

(*Continued from Vol. IV., page 616.*)

Fig. 4 shows the cost per kilowatt of generating plant and it will be observed again how the steam engine holds its own against its competitor in the sizes from about 750 kw. downwards. The figures also show that there is nothing gained, as far as the cost per kilowatt of turbine plant is concerned, by adopting the larger sizes, since owing to the reduced speed of the larger sets (1,500 revolutions per minute, as against 3,000 revolutions per minute) there is quite an appreciable increase in the cost per kilowatt. Hence, in the case of South Shields it was possible to instal 2,000 kw. turbo sets which probably cost no more per kilowatt than the large sets installed in the generating station of the Newcastle Electric Supply Company and without further expenditure on land,

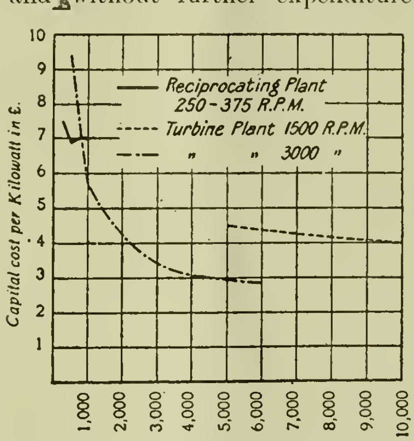


Fig. 4.—Capital Cost of Electric Generating Plant (including Turbine or Engine, Generator and Condensing Plant).

buildings, &c. It is in such cases as these that it will be extremely difficult to make out a favourable case for supplying in bulk.

With regard to steam generating plant a glance at Table III. will suffice to show that as far as the boiler-house plant is concerned, there is nothing like the same relative difference in cost between large and small units as exists in the case of the engine-room plant, although it should be pointed out that the figures do not include buildings, foundations, coal bunkers, conveyors, &c.

Table III.—Relative Cost of Steam Generating Plant, including Boiler, Superheater, Stoker, Economiser, Boiler and Economiser Brickwork and all Fittings, Ladders, Galleries, Doors, &c.

(Steam, 200 lbs. per square inch: Superheat, 200° F.; Coal, 12,000 B.T.U.'S.)

| Evaporation from and at 212° F. | Relative cost. | Cost per 1,000 lbs. steam. | Cost per kilowatt.* |
|---|---|---|---|
| 12,000 | 100 | £170 | £3·4 |
| 20,000 | 84 | 142 | 2·85 |
| 30,000 | 77 | 130 | 2·55 |
| 40,000 | 72 | 122 | 2·45 |
| 50,000 | 69 | 118 | 2·35 |

* All these figures are calculated on the basis of 20 lbs. of steam per kelvin.

Every electric supply engineer knows that it is quite possible nowadays under normal conditions to put down a very large power station for about £10 per kilowatt of plant installed, and it is more than likely that this figure might under very favourable circumstances be reduced to £8 per kilowatt. It can also be shown that a small station, say, 2,000 kw. to 5,000 kw., would not cost more than £20 per kilowatt, and a very small station (below 2,000 kw.), £30 per kilowatt. The larger station would have an advantage over the smaller one owing to the lesser proportion of stand-by plant, and also by reason of lower working costs.

For the purpose of showing as clearly as possible what might be done, under normal conditions, in the way of generating electricity on a large scale, Fig. 5 has been prepared. It will be noticed that in order to have some basis to work on, the figure 0·265d. has been taken as being a fair figure for total working costs in a station having a load of 80,000 kw. and a load-factor of 25 per

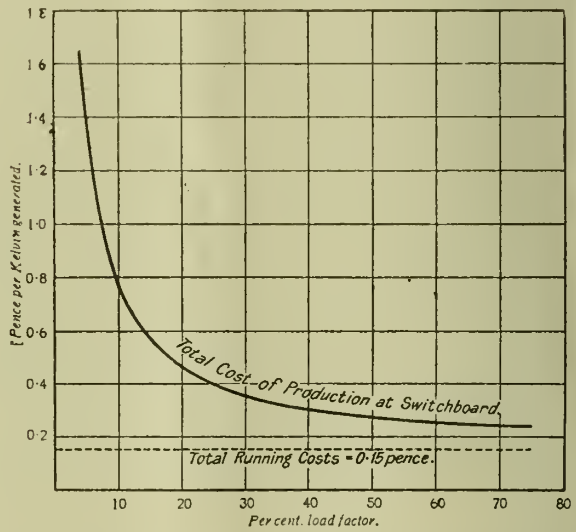


Fig. 5.

Fig. 5.—Estimated Cost of Production per Kelvin Generated for Generating Station of 100,000 kw. (Plant installed).

Load = 80,000 kw. Capital cost of plant installed = £1,000,000. Interest and sinking fund = £100,000. Total working cost (pence per kelvin) on basis of 25 per cent load factor and allocated as follows:—

| Item. | Fixed charges. | | Running charges. | |
|---|---|---|---|---|
| Coal, &c. | 25 p.c. | 0·04 | 75 p.c. | 0·12 |
| Oil, stores, water, &c. | 50 ,, | 0·005 | 50 ,, | 0·005 |
| Wages of workmen | 75 ,, | 0·015 | 25 ,, | 0·005 |
| Repairs and maintenance | 50 ,, | 0·015 | 50 ,, | 0·015 |
| Rent, rates and taxes | 100 ,, | 0·02 | .. | .. |
| Management, salaries, &c. | 100 ,, | 0·02 | .. | .. |
| Totals | | 0·115 | | 0·145 Say 0·150 |
| Total working cost | | 0·265 pence. | | |

Note.—Nothing outside generating station is included.

cent. This figure is split up into various items of cost, which in turn are divided into fixed charges and running charges.

In comparing the figures represented in this curve with those of Figs. 1 and 2, it must be remembered that since

the latter are average figures there are some stations which generate at a cost considerably below the average. Careful investigation would undoubtedly show that there are cases of comparatively small stations where it would certainly not pay to take a bulk supply. In the majority of cases, however, it would appear that a bulk supply would be of considerable advantage. It must not be forgotten that the curve represents an ideal state of things which can only be arrived at providing all, or at any rate most, of the existing undertakings agree to sink their individuality in that of the larger scheme.

### Transmission.

There does not appear to be any serious difficulty in the way of a bulk supply scheme from the point of view of transmission, except as regards the capital cost, which in the case of a large system might very nearly equal the capital cost of the generating station. It is also doubtful whether any responsible public electric supply engineer would care to run the risk of being entirely dependent on overhead lines for his supply. It would be advisable, therefore, that any hypothetical estimate of the cost of the transmission system should be based on underground cables, or on a combination of underground and overhead mains carefully interconnected and led to the point of distribution along different routes.

The disadvantage of the adoption of extra-high pressures is that step-up, as well as step-down, transformers would have to be used, with the result that the transformer losses alone would amount to a considerable sum per annum. In addition to the above losses it is necessary to allow for the losses in the cables, not to mention the heavy losses which will undoubtedly be incurred to direct-current or alternating-current at a different periodicity to that of the bulk supply system.

The author is of opinion that by the time all these things have been taken into account it will be a very difficult thing to prove that an isolated bulk supply authority is in a position to generate and distribute electrical energy at a price which will allow of a reasonable profit, although the case might be altered materially by the linking-up of other large undertakings in which case the capital cost per kilowatt of load could be substantially reduced.

### Conclusion.

It is desirable that steps should be taken thoroughly to investigate the whole question of electricity supply in this country, because every day increases the obstacles and delays electrical development. One of the obstacles to be surmounted is local jealousy. There are cases where such jealousy appears to have been overcome, and the author hopes that those who have experience of such cases will come forward and give the Association the benefit of their experience.

It would appear that the first thing to be done would be to appoint a representative Committee consisting of members of the I.M.E.A., and this Committee should have power to co-opt members of other scientific societies. The duties of such Committee would be to make a thorough investigation into the whole subject of electricity supply, with a view—

(*a*) To standardise as far as possible the generation and distribution of electricity throughout the whole country.

(*b*) To conserve the supply of fuel used in electricity works and to make a thorough investigation of the important question of extracting from the coal valuable by-products.

(*c*) To make use of waste-heat wherever possible.

(*d*) To cut down the percentage of spare plant by judicious linking-up of adjacent networks. (There are numerous instances where this could be done right away.)

(*e*) To promote legislation whereby facilities may be obtained such as are absolutely essential to the scheme and such as do not exist to-day.

*(Concluded.)*

## ELECTRIC POWER IN SLATE QUARRIES.

By G. K. Paton.

(*Continued from Vol. IV., page 613.*)

The following average results have been obtained in actual operation:—

1. Over a definite period 423 complete journeys were made (in and out), when the net tonnage lifted amounted to 887 tons. During this period the power used amounted to 650 units, equal to 0·733 units per ton, or 1·54 units per load of 42 cwt.

| No. | Operation. | Power in kw. | Distance. | Time. |
|---|---|---|---|---|
| 1 | Empty wagon lifted at mast ... | 22 | .. | Short lift, 20 ft. |
| 2 | Empty wagon lifted from pit .. | 25 | 150 ft. | 30 seconds. |
| 3 | Running out empty wagon .... | 10 | .. | .. |
| 4 | Lifting full wagon ............ | 55-60 | 165 ft. | 35 seconds. |
| 5 | Travelling in ............... | 10-15-20-30-40 | 900 ft. | 60 seconds. |

2. In another cableway the tonnage noted in 255 journeys was 574 tons, when the power consumed amounted to 516 units, giving 0·9 unit per ton lifted, or 1·89 units per load of 42 cwt. net.

These figures include journeys made with empty wagons, which must be taken into account in arriving at an average cost. The actual power in kilowatts for the various operations are given in the above table. A series of power readings were taken and the load weight checked to arrive at some idea of the general efficiency of a cableway. These are given in the following table:—

| —— | Kw. | Lifting Speed. | Overall effic. | Motor effic. | Cableway effic. |
|---|---|---|---|---|---|
| Lifting empty wagon ........ | 21 | 300 ft. | 32·5 | .. | .. |
| Lifting full wagon .......... | 60 | 300 ft. | 70·0% | 87·0% | 80·5% |
| Lifting load of blocks ....... | 70 | 300 ft. | 65·0% | 86·0% | 76·0% |
| Motor running alone ........ | 10 | .. | .. | .. | .. |

The loads being 9, 55, and 60 cwts. in each case.

Taking 200 tons per diem as a maximum, the consumption of power at an average of 0·8 unit per ton would be 160 units.

The average load requires a maximum power of 60 kw., or 70 B.H.P., which gives an average of 2·28 units per horse power per diem. Over a longer period the average would amount to only about 50 units per diem, equal to only 0·715 unit per horse power per diem. This is

equivalent to a load factor of, say, 9 per cent to a possible maximum of 28 per cent over a 10-hour day, and under normal working conditions 10 to 15 per cent would be a fair average.

From these results, which have been obtained under actual working conditions, it is now possible to tabulate and compare the costs and tonnage handled by each type. These are given below:—

| Type of cableway. | Cost of equipment. | Tonnage per diem. Max. | Tonnage per diem. Av. | Kw. | Units per ton. |
|---|---|---|---|---|---|
| | £ | | | | |
| Single incline hoist ......... | 600 | 400 | 130-200 | 60 | 0·48 |
| Double hoist ............... | 1,000 | 800 | .. | 120 | 0·48 |
| Aerial suspension cableway .. | 900 | 200 | 50-100 | 60 | 0·733-0·9 |

| Type of cableway. | Load factor. Max. | Load factor. Av. | Overall efficiency. | Remarks. |
|---|---|---|---|---|
| Single incline hoist ......... | 35% | 12·18% | 76% | Diagonal lift 300 ft. Travel 400 ft. |
| Double hoist ............... | .. | .. | .. | .... |
| Aerial suspension cableway .. | 28% | 10·15% | 65-70% | Vertical lift 165 ft. Travel 900 ft. |

The approximate cost given in column 2 includes complete electrical equipment, ropes, masts, buildings, foundations, and anchorages. The electrical equipment of the single hoist and aerial cableway is similar with 70 B.H.P. motors and controllers.

From the figures given it will be noted that the actual tonnage handled by the inclined hoist is practically double that of the aerial suspension cableway.

The advantage of a cableway is that a wagon may be hoisted or landed at any point along the span of the main cable, whereas with an inclined hoist the landing places are fixed.

Both types are taken advantage of in Penrhyn Quarry, the cableways spanning the open workings, and landing wagons on rails, on which they are taken under the inclined hoist. The hoist then lifts the wagons another 300 ft. to the level of the debris tips. One hoist deals comfortably with the tonnage handled by two aerial cableways. In this way 200 to 300 tons of debris per diem are removed from one part of the quarry workings, lifted a height of 400 ft. to 500 ft., and a distance of over 1,500 feet., at a power cost of about 1¼d. a ton.

The author next deals with air compressors and pumping.

### Bulk Supply.

As already stated, with the exception of a pumping load, a quarry demand is for 10 hours per diem, and this is reduced in winter to eight hours per diem.

It may be interesting to summarise the results obtaining from the different types of demand on the power company, and to indicate the proportion of each.

This particular plant may be taken to give average working conditions, although there is a preponderance of winding, and consequently peak load. The load factor taken over a day of nine hours is 43·5 per cent.

The load factor taken over a month and 24 hours per diem is 12 per cent.

The plant diversity factors

$$\frac{\text{Total H.P. installed in kw.}}{\text{Average max. load on chart}} = 2.$$

In other words, a demand of 250 kw. on the power plant will supply a quarry plant totalling 500 kw.

The ratio is still further increased by totalling the individual quarry horse power connected against the actual maximum demand on the power station, which gives a diversity factor of about three.

There are many advantages resulting from a bulk supply, and these may be enumerated briefly as follows: (1) The supply is available whenever required, night and day. (2) The supply is given within guaranteed limits of voltage and frequency. (3) Power used is directly proportional to work done; there are no stand-by losses. (4) Only one skilled man is required to supervise the secondary plant. (5) The power consumer can obtain from the meter readings his costs over any period, and know exactly what these costs are. (6) In this particular supply, from an hydro-electric power company, he is independent of coal, oil, or other fuel costs, which vary according to market and other conditions. (7) His immediate capital cost is low, and only includes the secondary equipment; the plant invariably increases owing to the facilities afforded for putting down new plant without considering cost of generating machinery. (8) He obtains his power at a price unobtainable under other circumstances.

In pre-electric days the lost time due to want of steam pressure was also noticeable, especially in the mornings. In one steam-driven slate saw shed, the cyclic variation on the main shaft is quite noticeable, and it is not unusual to find the speed about 50 per cent of normal, varying with the load and steam pressure. With electric power, however, the supply is available when the men start work, and no time is lost. Power is used only when useful work is done; and in slate sheds the cutting speed is constant within a few per cent, according to the slip on the motors.

In conclusion, while the present state of the slate trade may not warrant further capital expenditure, and each particular quarry must be considered by itself, the actual working costs with modern machinery are so small compared with the additional revenue from increased output and reduced working costs, that no quarry manager should be content to work under conditions which prevailed in the past. The cost of electric power and machinery is only one item, small when compared with other expenditure in a quarry; but it is one which will give a quick return and enable a manager to devote his energies to other problems in the production of slate.

*(Concluded.)*

## OIL ENGINES AND STEAM ENGINES IN COMBINATION.

By Geoffrey Porter, A.M.I.C.E.

*(Continued from Vol. IV., page 609.)*

Five years ago opinions differed as to the functions of a Diesel engine in a "mixed" station. Some said, "Work it for all it is worth and use the steam plant for peak-load and emergencies"; others said, "Run your steam plant all the time in order to keep down the preparation charge proportion, and use your oil plant for the peaks and emergencies, when its quick-starting and high-efficiency characteristics will be of the greatest advantage." I think it is now the general practice to work the Diesel engines "for all they are worth," and to keep the steam engines in reserve. At any rate, that is my own practice. In Table II., lines 6, 7, and 8 illustrate the point fairly clearly, and may be read in conjunction with the thermal efficiencies

given in line 11. Lines 12 and 13a indicate the effect of keeping boilers under steam for stand-by purposes.

In Table I. a comparison of the generating costs of the three stations before and after adopting Diesel engines is instructive.

| | | | | |
|---|---|---|---|---|
| "A" shows a reduction of | | ·358d. | per unit generated; | |
| "B" | ,, ,, | ·046d. | ,, | ,, |
| "C" | ,, ,, | ·276d. | ,, | ,, |

these figures being obtained in the face of rising fuel prices. Similarly, the overall thermal efficiencies have improved as under:—

| | | | | | |
|---|---|---|---|---|---|
| "A"—Thermal efficiency rose from | 4·93 p.c. | to | 22 6 p.c. | | |
| "B" ,, ,, ,, | 6 1 | ,, | 10·5 | ,, | |
| "C" ,, ,, ,, | 2·6 | ,, | 6·5 | ,, | |

These figures depend, of course, on the proportion of the units generated by oil as a percentage of the total units generated. "B" having a steam plant of five times the capacity of its oil installation was obviously unable to make so great a reduction as was "A," where the proportion was roughly 1 to 1; and "C" 1·6 to 1. The greatest reductions are in the items fuel, wages, and repairs. It should be pointed out that Stations "B" and "C" include in the "wages" item the proportion of "salaries" of the engineering staff, which is stated separately in line 19 of Table I. for Station "A."

I refer you at this point to Table III., which shows the cost of fuel per unit generated for Station "A" at various load factors for the steam and oil sections of the plant. The pair of curves, Fig. 1, shows the comparison graphically. Coal cost 18s. 3d. per ton, fuel oil was 64s. per ton. The figures are taken from the ordinary weekly records, and are the result of every-day running conditions. From approximately full load down to half-load there is a drop of 6·3 per cent in the steam figures, and over a corresponding series there is one of 20 per cent in the oil figures.

A statement of some of the "vital statistics" of eight generating stations having both steam and oil plants may be of interest; it shows a general tendency towards improvement in the financial position since the Diesel engine was adopted.

| Station. | Reduction in fuel cost per unit sold. | Gross profit per kilowatt of maximum load before oil plant. | Gross profit per kilowatt of maximum load after adopting oil plant. |
|---|---|---|---|
| | d. | £ | £ |
| 1 | 0·31 | 11·3 | 14·1 |
| 2 | 0·23 | 9·9 | 10·5 |
| 3 | 0·20 | 8·8 | 14·3 |
| 4 | 0·18 | 11·1 | 15·2 |
| 5 | 0·20 | 3·37 | 6·9 |
| 6 | 0·21 | 8·4 | 10·2 |
| 7 | 0·11 | 9·8 | 11·5 |
| 8 | 0·06 | 13·4 | 15·1 |

I regret that the figures in this table are not arranged on quite the same lines as are the figures in the other tables. In the time available I was unable to obtain the number of units generated in each case, hence the unit "sold" is here the basis of the calculation. The Diesel engine has this important advantage over the steam equipment. If valves are leaking and adjustments are not in order the fact becomes quickly obvious. The indications on the gauges (and there are not many of them) draw one's attention to irregularities. But a steam engine may run beautifully to the outward eye and ear, although piston valves and piston rings may leak, and the valve settings may be wrong owing to eccentric strap wear; the boiler settings may be drawing many cubic feet of air into the flues; the fires may be too thick or too thin. In very many cases, provided the main steam gauge is showing about the correct steam pressure, there is a general feeling of satisfaction with the aspect of affairs

Personally, I managed to improve the steam costs of "A" by 20 per cent or so by the aid of flue thermometers, draught gauges, flue-gas analysers, and graduated staffs in the boiler feed-water tanks; but even at that the benefit was but a fraction of that gained by purchasing plant that was inherently more efficient from the thermal point of view. Putting the three things together, capital charges, running costs, and gross profits, the advantage accruing from the use of the Diesel engine for installations within the limits of those indicated in this paper is manifest. The figures quoted for "A" showed the combined annual capital charges for interest and redemption to be £1·95 for a mixed steam and oil plant, and £1·62 for a steam plant only, the difference being one of 20 per cent. Taking the running costs for the last completed financial year, the reduction in running costs from those obtained in pre-oil days was no less than 34·4 per cent.

In concluding this section of the paper I should like to urge on all Diesel engine users the great value of the indicator diagram as a quick and ready means of testing the condition of an engine. The "hand-drawn" cards are particularly valuable as showing the distribution of the fuel oil among the cylinders. If cards are taken and filed for reference and comparison, it is not difficult to keep an engine well up to its test results. The outlay of £10 to £15 on an indicator set is a small matter in comparison with the losses that may occur if an engine is not periodically checked.

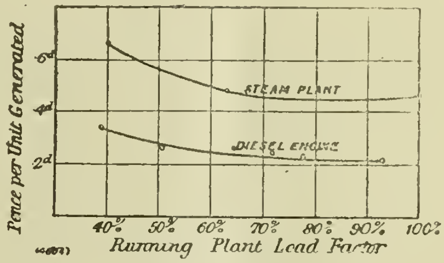


Fig. 1.

The choice of the most suitable Diesel engine to accept when confronted with a number of them is not easy. All members of this association are now acquainted with the features which are and are not desirable in an engine. But, when taking the plunge in the first instance, the choice was difficult. Some engineers embraced the lowest tender with the affection frequently accorded to that interesting hybrid, others did not. Manufacturers' representatives were very kind, but exhibited a considerable admiration for the merits of their own particular variety of Diesel engine, and in this respect no other attitude could be looked for.

The attractions of the lowest tender are, of course, almost irresistible. In my judgment the lowest tender is suspect if it be more than 5 per cent below the average of the other tenders. I do not venture to lay down any rule for the guidance of anyone in this matter, but I will go so far as to say that my own preference is for (1) a low piston

speed; (2) a low mean effective pressure from the full load card; and (3) a low piston and crank-pin loading. The general design of the crank-shaft and its bearings, the gudgeon pins, and the lubricating arrangements throughout must, of course, be examined also.

The transition from the paper stage to the practical one of operating the Diesel engine not unnaturally brought to light a number of occurrences with which engineers were not familiar. Many were trivial in their nature, others were serious. Many engineers solved their problems by means of their own skill, others grumbled and lost heart and interest. In course of time it was felt that a central body competent to collect and compile records and to act as a standardising authority to some extent was a necessity. In this way the Diesel Engine Users' Association came into being. From a very modest and quite informal beginning this association is growing steadily, and will, I trust, one day assume a very important position in the domain of the internal-combustion engine.

TABLE III.—Comparative Fuel Costs per Unit Generated on a Load Factor Basis, extracted from the Weekly Records—Station "A."

| Running plant load factor per cent ... | 38·9 | 40·0 | 50·1 | 62·5 | 64·5 | 70·3 | 76·8 | 91·5 | 98·0 |
|---|---|---|---|---|---|---|---|---|---|
| Steam plant pence .. | .. | 0·625 | .. | 0·48 | .. | .. | .. | .. | 0·45 |
| Diesel plant ,, | 0·332 | .. | 0·260 | .. | 0·255 | 0·223 | 0·220 | 0·208 | .. |

Coal at 18s. 3d. per ton; fuel oil at 64s. per ton.

TABLE IV.—Schedule of Particulars obtained from Manufacturers in submitting Tenders for Diesel Engines.

| Tender 1. | B.H.P. | No. of Cylinders. | B.H.P. per Cylinder. | Revs. per Minute. | M.E.P. from Full Load Card. | Cylinder Diameter. (Inches.) | Length of Stroke. (Inches.) | Piston Speed per Min. (Feet.) | Ratio Stroke—Bore. | Ratio of Price Accepted to Lowest Tender. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 400 | 3 | 133⅓ | 187 | 82 | 20 | 28·4 | 885 | 1·42 | 1·64 |
| B | 400 | 4 | 100 | 175 | 99 | 18 | 26·0 | 758 | 1·41 | 1·26 |
| C | 375 | 3 | 125 | 200 | 95 | 18 | 26·0 | 866 | 1·44 | 1·20 |
| D | 375 | 3 | 125 | 200 | 84 | 20 | 24·0 | 800 | 1·20 | 1·20 |
| E | 400 | 4 | 100 | 175 | 72 | 17¾ | 24·75 | 721 | 1·40 | 1·18 |
| F | 400 | 4 | 100 | 187 | 72 | 17 | 25·25 | 786 | 1·48 | 1·18 |
| G | 400 | 4 | 100 | 180 | 92 | 17¾ | 26 | 780 | 1·46 | 1·04 |
| H | 385·8 | 3 | 128·6 | 175 | 95 | 18¾ | 28 | 815 | 1·49 | 1 |
| I | 400 | 4 | 100 | 175 | 95 | 17½ | 26½ | 773 | 1·51 | 1·04 |
| | | | | | | | Av. | 798·2 | | |
| Tender 2. | I.H.P. | | | I.H.P. per Cylinder. | | | | | | |
| A | 256 | 4 | 64 | 250 | 100 | 12 | 18·1 | 755 | 1·51 | 1 |
| B | 260 | 4 | 65 | 250 | 100 | 12 | 18·25 | 761 | 1·52 | 1·159 |
| C | 266 | 4 | 66·5 | 250 | 88·8 | 13⅜ | 16⅞ | 700 | 1·26 | 1·165 |
| D | 296·1 | 3 | 98·7 | 300 | 98·7 | 13⅜ | 16⅞ | 842 | 1·36 | 1 |
| E | 266·1 | 3 | 88·7 | 190 | 101·7 | 14¼ | 22⅛ | 700 | 1·55 | 1·186 |
| F | 210 | 3 | 70 | 210 | 82 | 13⅞ | 18⅞ | 661 | 1·36 | 1·294 |
| | | | | | | | Av. | 735 | | |

A recapitulation of all the subjects we have discussed at our meetings would be wearisome, and, indeed, impossible within the scope of this paper. I should like, however, to draw your attention to three subjects which have been of great interest and which are far from being exhausted. The first is the problem of the lubrication of Diesel engines. We collected a large amount of information and data on this subject and discovered a series of remarkable discrepancies in the course of our investigations. An endeavour to lay down any definite pronouncement in the matter of how much or how little oil should be used for various engines was found to be impossible at the time. Mr. C. O. Milton, one of our most energetic members, gave us a communication on the subject and contrived to establish some relations between the lubrication of engines and the conditions under which they are used; but even here he lighted upon two series which did not agree, and for whose disagreement there did not appear to be any reason. We had hoped that Mr. G. E. Windeler would have given us some useful hints on the subject this evening, and doubtless he would have done so had he been able to read his paper on "Methods and Difficulties in Lubrication in Diesel Engines." The actual rate of the destruction of lubricating oil in the cylinder of a Diesel engine is a matter which would, I am sure, well repay a careful investigation. I trust we shall return to this subject in the not too distant future.

We are at present engaged in investigating the vagaries of air compressors. In general they work well; but occasionally they show bad habits. The committee of the association have a report on the subject in hand, and hope to bring it before the association before long. There are differences of opinion among our members, and not unnaturally so—we are not a "mutual admiration society"—and the happy mean will doubtless be struck. One feature, however, emerges as being of paramount importance, and that is, the behaviour of oil-impregnated vapours under the influence of high pressures and temperatures. I think it is a line of investigation eminently suited to the labours and talents of the National Physical Laboratory. I trust that institution may be persuaded to take it up in the future. Users, manufacturers and Government officers unite in recognising the necessity for the discovery of the real properties of these vapours.

Last, and perhaps of the greatest importance, is the question of fuel-oil supplies. This is a mater of vital importance to the whole industry. The present state of war has opened our eyes in many instances to the manner in which this great and rich country has become dependent on other communities for absolute necessities. The fuel-oil question can be and will be solved by our own chemists and engineers. The matter is of more than sectional interest; it is a national interest.

Our engines will work well on the products of the distillation of coal—British coal—that coal which is used to-day so uneconomically that at the best but 15 per cent to 20 per cent of its available energy value is actually utilised. Continental users and manufacturers have used tar oils and tars with the greatest success for many years in their Diesel engines, and we can do so too. The cost of adapting an existing engine for the purpose is not excessive, and under present conditions, at any rate, such cost will be abundantly repaid.

There is an opening for a new market for the by-products of gas works, blast-furnaces, gas producers and low-temperature coal distillers which should be well worth culti-

vating. When that is established we shall be, in one direction at least, an independent people. England's greatest commercial asset is her coal; her position in the trade of the world is chiefly due to this gift of the gods. It is the business of manufacturers and users of power plants in particular that it should be adequately conserved. In working our coal deposits we are indeed living on our capital; the greater the reason, then, to use it to the best advantage. With these remarks I will bring this paper to a close, and trust that the figures I have put before you have been sufficiently interesting to merit your attention.

*(Concluded.)*

## FRICTION AND POWER LOSSES.

By Edward Ingham.

Since the days when machinery was first made use of, the engineer has been devoting his best efforts to reducing to the lowest possible extent the friction or the resistance to motion which always exists between the various rubbing parts of machines.

### Engineers and Friction.

Many engineers regard friction as an unnecessary evil, because it is responsible for the loss of a very large proportion of the world's power, and some indeed think what a great pity it is that friction cannot be entirely eliminated. Such engineeers, however, have probably never considered what would happen if all friction were removed. The slightest consideration is sufficient to show that without it life would scarcely be possible. In the first place, if there were no such thing as friction the very act of walking would be impossible, because we depend on the friction existing between out feet and the ground for urging ourselves forward. The difficulty we experience in walking over ice or other slippery surface is entirely due to the comparatively small amount of friction which exists between our shoes and the ice.

Again, any body in motion would continue so for ever, unless it met some obstacle. Without friction a locomotive or other vehicle could not be set in motion; whilst if it were in motion, there would be no means of bringing it to rest except by placing some obstacle in its path.

We see, then, that friction is one of the essentials of life, but so far as the driving of machinery is concerned, it is to our interest to reduce it to within very narrow limits.

### Horse Power and Friction.

At the present time, the total horse power developed in the United Kingdom will probably exceed 20 millions, and it would appear that considerably more than one-half of this amount is used up in overcoming friction. The friction losses which occur may be divided up into three sections, viz., those in the engine itself, those in the line shafting, and those which occur in the machines to be driven.

From numerous experiments which have been made from time to time, we are able to form a fairly good idea of the extent of the losses which take place in the engine itself.

A good modern steam engine working on full load will have a mechanical efficiency of roughly 90 per cent. In other words, the ratio, $\frac{\text{B.H.P.}}{\text{I.H.P.}} = \cdot 9$, so that of the total power supplied to the engine in the form of heat energy, about one-tenth is used up in overcoming the friction of the engine itself. In the case of an inferior engine, where the lubricating arrangements are unsatisfactory and the working parts generally neglected, the mechanical efficiency may be as low as 60 per cent. In other words, nearly one-half of the indicated power is wasted in overcoming the friction of the engine. This illustrates the importance of lubricating all the rubbing surfaces in the most efficient manner, and of keeping the engine in first-class condition.

### Mechanical Efficiency of an Engine.

The mechanical efficiency of an engine falls off very rapidly as the load is reduced. Since the first law of friction states that "friction is directly proportional to the load," one would naturally expect to find that the friction of an engine when running with a heavy load would be much greater than it was when the engine ran light, but, as a matter of fact, this is not the case. Experiments made by Dr. Thurston and others have shown conclusively that the friction of an engine is practically constant for all loads, a fact which is not recognised by many engineers. Hence the power lost in overcoming friction, although not proportionally large in a good engine running at full load, may be serious at light loads. In the case of a lightly-loaded engine of inferior construction it will be seen that the frictional loss will be excessive in relation to the total power supplied to the engine.

### Where Friction Occurs.

There are, of course, numerous parts of an engine where frictional losses occur, but the principal parts are the main bearings, the pistons, the connecting-rod ends, the crosshead, the eccentrics, and in the case of a slide-valve engine, the valves.

According to Prof. Charnock, the main bearings absorb from 6 to 8 per cent of the total power of a good engine running at full load, and from 30 to 40 per cent when running only at one-quarter load. The question of lubrication of the main bearings is consequently of the first importance.

As regards the frictional losses which occur in connection with the line shafting, these vary within very wide limits, but it cannot be questioned that they are in many cases excessive, sometimes amounting to more than one-half of the total power developed.

In a paper read not long ago before the Junior Institution of Engineers, Mr. W. A. Tookey gave some interesting figures referring to the power absorbed by shafting in small factories. At one wood-working factory the normal brake horse power of the engine was 7·3 and the maximum 25·0. The power lost in shafting and belt friction was 1 B.H.P., viz., 13·7 per cent of the normal power and 4 per cent of the maximum.

In another similar factory the normal brake horse power was 9·5 and the maximum 24·0. The power lost in overcoming the friction of the shafting and belting was 8·5, which amounts to 90 per cent of the normal power and 35·5 per cent of the maximum.

At a machine-tool factory the normal brake horse power of the engine was 84·0, the maximum 138, and the power lost in friction 23 B.H.P., *i.e.*, 27·5 of the normal and 16·7 of the maximum.

At a grinding factory, where the normal and maximum powers were both 41, the frictional loss was 24·5 B.H.P., which is 60 per cent of the normal and maximum powers. These figures, which are the results of actual tests, will serve to show how the frictional losses vary at different factories, and how serious they may be,

### Power to Overcome Friction.

As regards the power required to overcome the friction of the various types of machinery employed in mills and factories, there is unfortunately little information available, but the power expended in the actual operations which the machines have to perform is without doubt a very small fraction of the power developed by the engine. This is particularly the case at a cotton mill, where it is estimated that the power required to drive the machinery, exclusive of the work of handling and manufacturing the cotton, amounts practically to 85 per cent of the total.

It will be gathered from the foregoing remarks that there must be considerable scope for reducing frictional losses at many factories and workshops, and the importance of conducting tests to ascertain the conditions and remove undue losses cannot be over-estimated. The frictional losses may often be reduced very materially with little difficulty. In one instance a reduction of 15 per cent of the power required for the shafting at a textile mill was effected merely by changing the lubricant. There can be no doubt that the question of lubrication is of the utmost importance, and the power user will generally do well to employ the most suitable lubricant irrespective of price. The selection of the most suitable lubricant for any given case can, of course, only be made by careful consideration and testing, but unfortunately the average power user will not go to any trouble or expense in this direction. In most factories no efforts are spared to reduce the fuel consumption per indicated horse power per hour to the lowest possible figure, but it is equally important that all possible attention should be given to the proper lubrication and design of the bearings, correct alignment of shafting, etc., in order that the excessive frictional losses which occur may be reduced to the minimum.

## THE DESIGN AND GRINDING OF METAL-CUTTING TOOLS.*

By J. Wendall Cole.

### Man a Tool-using Animal.

Man has been described as "The Tool-using Animal": The invention of the Whitworth screw-feed lathe was a great stride in bringing a rapid duplication of standard work over the hand turning of previous practice. Another leading step for standard duplication of product is the machine grinding of the cutting tools—to have their angles and shapes standards and duplicates. First design the steel-cutting tool with proper proportions and angles for strength, for clearance, and for cutting the metal, whether for cast iron or steel.

### Tool Design and Angles.

On tool design and angles, William Kent, in the seventh edition of his "Machinery Engineering Pocket-book," quotes "Hütte," the German engineer's pocket-book, giving the following cutting angles for using least power:—

| | Rake. Top | Cutting Edge. Angle of |
|---|---|---|
| Wrought iron ... ... | 3 deg. ... | 51 deg. |
| Cast iron ... ... ... | 4 deg. ... | 51 deg. |
| Bronze ... ... ... | 4 deg. ... | 66 deg. |

The best angles must, however, be guided by experience.

* Abstract of paper read before the American Association for the Advancement of Science.

### The Round-nosed Tool.

Mr. J. Sellers Bancroft says in Vol. 28 of the "Transactions of the American Society of Mechanical Engineers": "In 1869 I made a number of experiments at the works of William Sellers and Co., where I was then shop foreman, and demonstrated that the round-nosed tool would take a cut having a feed from 25 to 33 per cent coarser than the diamond-point tool would take in the same material and same depth of cut, with the added advantage that on cast iron, the final chip being so much thinner, the material was left in much better shape for the finishing tool. The advantages of this form of tool and the importance of having uniform angles of clearance and top rake, showed the importance of having these tools ground by machine, and in 1874, former slide rests, arranged to attach to regular grindstone boxes, were put into service and used regularly for this purpose. The advantages of this system were so apparent that in 1864 a more fully organised machine was constructed, using a special form of emery wheel on which all tools used on the machines, whether for lathe or planer, external or internal work, or screw-cutting, could be finished to definite angles and sizes, and thereafter all tools used in the shops of William Sellers and Co. were so ground. In 1883 a long series of experiments were tried on a 48 in. lathe to determine the power required for various depths and widths of cut, on both steel and cast iron, and the information thus gained was used thereafter in the designing of machine tools.

The late Fred W. Taylor, past-president of the American Society of Mechanical Engineers, says in his paper, "On the Art of Cutting Tools," Vol. 28 of the "Transactions": "Why cutting edge of tool should be curved: Principal object in having the cutting edge of tool curved is to ensure against damage to the finished work"; and again, in the same paper: "Tools with broad noses having for their cutting edges curves of large radius best to use except for risk of chatter."

### The Question of Chatter.

Upon this question of chatter Dr Nicolson, in describing his experiments, published in "Transactions," Vol. 25, says: "The wave length of the force curve is about 0·6 in. for this experiment, and it varies between 13,000 lbs. and 8,000 lbs. It will be observed that the force attains a maximum soon after the cutting commences to crack or shear across, and that it drops to a minimum when the small piece of cutting falls off the forging. At such a slow speed as this (1 ft. in five hours) the cutting has time to shear off right across in separate fragments, whereas it forms a continuous curl of considerable rigidity when the cutting speed is higher than a few feet per minute."

### Mr. F. W. Taylor's Conclusions.

From these experiments and his own experience, Mr. Taylor concludes in Vol. 28: "Since the thickness of the shaving is uniform with straight edge tools, it is evident that the period of high pressure will arrive at all points along the cutting edge of this tool at the same instant and will be followed an instant later by a corresponding period of low pressure; and that when these periods of maximum and minimum pressure approximately correspond to, or the forging, the tool, the tool support, or in any part of the driving mechanism of the machine, there will be a resultant chatter in the work. On the other hand, in the case of tools with curved cutting edges, the thickness of the shaving varies at all points along

the cutting edge. From this fact, coupled with Dr. Nicolson's experiments, it is obvious that when the highest pressure corresponding to one thickness of shaving at a given point along a curved cutting edge is reached, the lowest pressure which corresponds to another thickness of shaving at another part of the cutting edge is likely to occur at about the same time, and that therefore variations up and down in pressure at different parts of the curve will balance or compensate one for the other.

"It is evident, moreover, that at no one period of time can the wave of high pressure or low pressure extend along the whole length of the curved cutting edge. For this reason a curved cutting edge tends to prevent chatter."

### Reasons for Adopting Particular Curves.

Continuing, he says: "Reasons for adopting the particular curves chosen for the cutting edges of our standard tools: It will be noted that as the body of the tool becomes smaller, the radii of curvature of the cutting edge also become correspondingly smaller. This change in the curve of the cutting edge is rendered necessary by the fact that the smaller tools are used in the small lathes, which, generally speaking, work upon small forgings from which cuts are removed which are both shallow in depth and have comparatively fine feeds. Forgings which are small in diameter are quite as liable to chatter as the larger forgings which are machined in larger lathes, and in order to avoid this chatter it is necessary that a curve for the cutting edge should be chosen which will give a variation relatively in thickness of shaving even in small depths of cuts. Thus, for the avoidance of chatter, the curve of the cutting edge should be small in proportion as the depth of cut and feed which it normally takes are small."

As will be seen later, the small radius of curvature of the cutting edge involves a diminution in cutting speed. Therefore, with larger sized tools it becomes important, on the other hand, to take as large a radius of curvature for the cutting edge as is compatible with freedom from chatter. The coarser feed which usually accompanies the larger tool also calls for a larger radius of curvature at the nose of the tool, in order that the ridges left by the spiral path of the tool along the forging shall be as low as practicable.

### Adaptability of the Standard Tool.

The all-round adaptability of the standard tool to a variety of uses also calls for a smaller radius of curvature the smaller the tool, since standard roughing tools are continually required to run up against a shoulder or into a corner of the work, and the fillet in this corner is normally small in proportion as the forging or casting is small. Tools which are to be used for cutting cast iron and hard steel have slightly larger radii of curvature than those which are to be used for the softer steel and wrought iron. The reason for this change is that much slower cutting speeds must be used in cutting hard steels than for soft, and this is also to a less degree true for cast iron as compared with soft steel.

Cast iron is cut with less cutting pressure or resistance to the tool than is required for soft steel. Therefore, in a given lathe a greater depth of cut and coarser feed can be taken on cast iron than on soft steel: and, as explained before, the coarser the feed the greater should be the radius of curvature of the extreme nose of the tool in order to leave an equally smooth finish. Where local shop practice calls for a comparatively shallow cut and broad feeds, such shops should have standard tools especially designed for such work.

### Clearance Angle of the Tool.

The following are our conclusions regarding the clearance angle of the tool:—

(*a*) For standard shop tools to be ground by a trained grinder, or on an automatic grinding machine, a clearance angle of 6 deg. should be used for all classes of roughing work. (*b*) In shops in which each machinist grinds his own tools a clearance angle of from 9 deg. to 12 deg should be used, because hand grinding varies so much.

The larger the clearance angle the greater will be the ease with which the tool can be fed (wedged or driven) into its work. On the other hand, every increase in the clearance angle takes off an equal amount from the lip angle, and therefore subjects the tool to a greater tendency to crumble; the clearance angle must be sufficiently large to avoid rubbing the flank of the tool against the spiral flank of the metal being cut.

### Lip Angle of the Tool.

In brief, Mr. Taylor's conclusions may be stated: For standard tools for cast iron and the harder steels grind with a clearance angle of 6 deg., back slope 8 deg., side slope 14 deg., giving a lip angle of 68 deg.

For cutting steels softer than, say, carbon 0·45 per cent having about 100,000 lbs. tensile strength and 18 per cent stretch, tools should be ground with a clearance angle of 6 deg., back slope of 8 deg., side slope of 22 deg., giving a lip angle of 61 deg.

The most important consideration in choosing the lip angle is to make it sufficiently blunt to avoid the danger of crumbling or spoiling at the cutting edge.

When such tools have been designed for the work in hand, for the best results in grinding, the steel tool should be held in a chuck and presented to a V-shaped wheel "with 90 deg. included angle, for convenience in grinding the different faces of tools, for increasing the available grinding surface, and to enable small and delicate splining tools to be ground." Also, that a tangential line contact of wheel and surface ground can always be maintained, thus permitting a constant flood of water upon the line of contact, and allowing much more rapid grinding than where the wheel and tool have a surface contact. "The tool-chuck can be rotated about a horizontal axis parallel with the shanks of the tool, and can readily be set up to any angle by means of a graduated circle and vernier reading to 1/10 deg. It is carried in a frame which can be rotated about a vertical axis passing near the point of the tool, and can be set to 1/10 deg." Thus it becomes a universal tool grinder for all shapes and sizes except concave.

Engineers have in recent years advised and perfected standard work in all lines of manufacture, and capitalists are rapidly adopting these standards in leading lines. But many financial managers, and also some engineers, are not aware of the fact that while adopting standard construction, cranes, machine tools, steels, and foundry metal to make a standard product they are overlooking a very important link in the chain of production when they omit standard shapes of cutting tools. One weak link measures the power of the chain.

The whole object of an engineering works from purchase of real estate to sale of product is to change rough metal into finished product the most rapidly and with the least expense. The keynote of the whole production is the angle

of the cutting tool. More chips, size of pay-roll, and dividends all depend upon it.

To get the benefit of high-speed steel tools they *must* be ground at proper angles, for if used upon old machine tools the wrong angles of a majority of hand-ground tools soon wreck the machine tools. If used upon modern machine tools designed for using high-speed steels, the difference in strain between using proper angles in the cutting edge and wrong guesswork angles may run into tons, cause tools to dull sooner, a loss of time in changing tools, and a waste of not only high-speed steel, but at present very high-priced steel, in dulling and needing grinding so soon again.

## ANNEALING OF ARSENICAL BRASS.

A paper, by C. H. Mathewson and E. M. Thalheimer (Yale University, U.S.A.) entitled "The Annealing of Arsenical Brass containing 61 per cent and 62·5 per cent of Copper: A Study of the Structure and Properties Developed by Varying the Rate of Cooling Within the Transformation Range," was presented to the Institute of Metals. During the summer of 1914 the authors were called upon to make tests for the purpose of selecting a brass mixture based upon the use of Copper Range copper—a "Lake" brand containing about 0·3 per cent of arsenic—and of specifying forms of heat treatment which would give satisfaction in the manufacture of heavy tube. The particular process for which this material was intended consists essentially in hot-rolling a thick cake to a circular disc about ½ in. thick, annealing and then cupping the disc, after which tube is produced by a number of closing-in and drawing operations, each preceded by annealing treatment. It is thus apparent that the material must be adapted to hot working, and, in addition, must possess a high order of ductility when cold, so that it may flow freely between the punch and die. As a result of preliminary tests on several mixtures, the authors recommended material containing 62·5 per cent of copper, which, as ordinarily cast from Copper Range copper, would contain not more than 0·16 per cent of arsenic. Using a high grade of spelter there would be no difficulty in hot-rolling brass containing a considerably higher percentage of copper than this. It is their impression that the hot-rolling properties of these alloys are largely dependent upon the lead-content and the amount of the Beta constituent present at the rolling heat. The main purpose of this paper is to present the results of tests which show comparisons between the properties of brass containing (1) 62·5 per cent of copper and very little arsenic (0·024 per cent), (2) 62·5 per cent of copper and considerable arsenic (0·120 per cent), and (3) 61 per cent of copper and considerable arsenic (0·139 per cent) after different forms of heat treatment. In general, it may be said that brass of this character made from arsenical copper is likely to afford a better combination of strength and ductility than metal made from electrolytic copper when both are properly annealed. The authors are convinced that arsenical brass of this type will meet severe hot and cold-working requirements. With regard to heat treatment, it is agreed that, in order to obtain the most favourable conditions for cold-working a brass containing 61 per cent of copper (and this probably applies to ordinary Muntz metal containing 60 per cent of copper), annealing, if conducted at temperatures above moderate red heat, should be followed by at least a moderately slow rate of cooling, say, 20 deg. Cen. per minute, and slow cooling should be continued to a temperature not far above 450 deg. Cen. If the metal is higher in copper, viz., if it contains some 62 per cent to 63 per cent of copper, emphasis should be laid on very slow cooling; for example, a 5 deg. rate is far more satisfactory than a 20 deg. rate, and in such case the metal should be allowed to cool normally to some 550 deg. Cen., whereupon it may be quenched in a stream of water if desired. In case a rate of cooling in excess of 20 deg. Cen. per minute prevails, it will be advantageous to allow such cooling to proceed unchecked to 450 deg. Cen., or even a lower temperature.

## BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

(*Continued from Vol. IV., page 583.*)

Heat Transmission.

### Water Circulation.

It is evident, from the facts given in the preceding article, that the velocity of the water over the heating surface has an important influence on the rate of heat transmission. The boiler design therefore should always be such that arrangements are provided for the quick movement of the water over the plate and the easy liberation of the steam produced. In other words, quick natural circulation of the water should be a primary consideration in any boiler design, and in so far as the design does not provide for this, the boiler will fail to respond to variable steam demands, and increased energy will be absorbed in maintaining even moderate circulation.

### Causes of Natural Circulation.

There are three distinct causes which tend to produce circulation of water in a steam boiler:—

(1) Difference in density of water due to variation in temperature when the fires are first lighted and before steam is generated.

(2) When the water has attained the temperature at which steam is generated, circulation is produced by the entraining action of the steam bubbles rising through the water.

(3) When steam is being generated rapidly, the mixture of steam, foam, and water in the rising portion will have a much less density than the feed water, and rapid circulation will then take place with correct designs of steam boilers.

As the feed water in modern boiler practice is supplied to the boiler at as near the steam temperature as possible, we need not consider the first cause, but to so arrange our design that every facility is provided for the second and third cause producing the maximum effect. The water circulation must be governed and directed if the highest efficiency and evaporation are to be obtained.

In order to do this it is essential that the area and formation of all water spaces and passages should be such as to give the greatest liberty to the water movements. Adequate provision must be made for the feed water easily and completely taking the place of the generated steam, and also that the steam has facility for easily separating itself from the water without the latter being intimately mixed with the steam. The importance of

these points was shown many years ago by Wye Williams, and as far as smoke-tube boilers are concerned, at any rate, his ideas are still correct. Williams described many experiments he had made to determine the movements of water under varying conditions when heat is applied, and although the experiments were not made under working conditions, yet they indicate the importance of a correct knowledge of the water movements if the best results are to be obtained from the boiler.

Fig. 69 shows a tall, narrow glass attached to a tin vessel, and in which water is heated by means of the lamp. When the water commences to boil it will be found that instead of steady circulation, "the descending water will be so obstructed by the joint columns of ascending water and steam that both are thrown into great confusion, their respective currents continually changing sides and the progress of evaporation considerably delayed. We here obtain a clear practical view of what must take place between the flues or tubes of boilers with their usually restricted waterways."

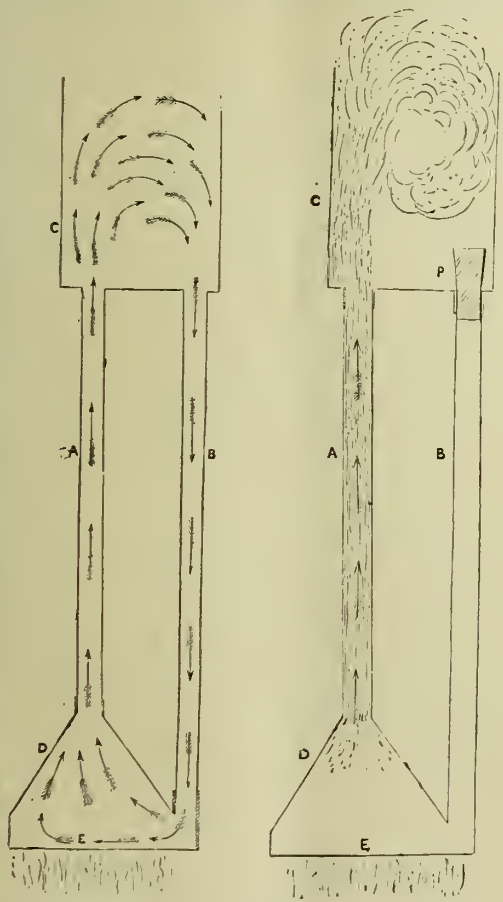


Fig. 69. Boiler-House Efficiency. Fig. 70.

## An Important Experiment.

Another of Williams's experiments, and one of great importance, was made with the apparatus shown in Fig. 70. Two glasses, 2 in. diameter and 18 in. long, A and B, are connected by a tin apparatus C and D at the top and bottom. This apparatus was filled with water and heat applied. A current of mixed steam and water will be seen ascending in one glass and water descending in the other as indicated by the arrows in the first figure. It will be apparent that no confusion or collision can take place—a condition favourable to the generation of steam—whilst the colder water finds easy access to the heating surface at E.

If now the communication between the two glasses be cut off by inserting a cork or plug in one of the glasses as seen at P in the second figure, a condition arises which Williams describes as follows:—

"The circulation in glass B will be suspended, and the glass A will then have the double duty to perform of allowing the rising steam to reach the surface and the descending water to reach the bottom at E. The previous uniform generation of steam will then be succeeded by an intermittent action, explosive violence alternating with comparative calm and inaction, clearly indicating that the latter is only the interval of accumulating force to be discharged by the former. The *rationale* of this intermittent action is that the water, being obstructed in its descent, the steam is necessarily delayed or accumulated in the lower chamber and only discharged at intervals."

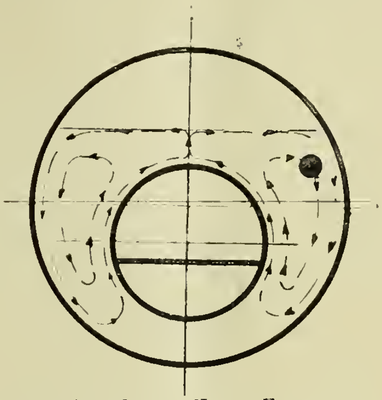

Fig. 71.—Boiler-House Efficiency.

"Again, this accumulated steam, getting sudden vent, is discharged with great violence, literally emptying both the glass and the lower chamber. An equally violent but more sudden reaction, of course, follows, and a large body of colder water as suddenly rushes down to fill the space vacated. An interval will then necessarily be required to raise the temperature of this large supply of colder water and restore the previous state of ebullition."

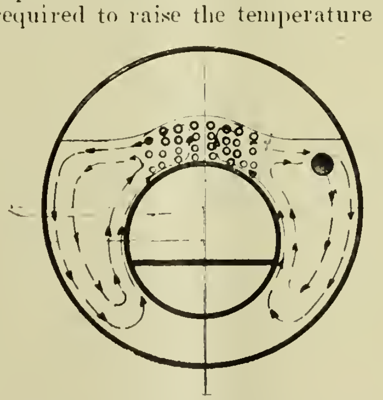

Fig. 72.—Boiler-House Efficiency.

In this experiment the effect is clearly demonstrated of restricting the formation and area of the water passages, of preventing the continuous and free access of water to the heating surface, and of causing intimate contact and mixture of the steam and water. If the circulation is impeded by the want of adequate water

space, the steaming power of the boiler will be limited, difficulty will arise through overheating of surfaces, and priming will certainly take place except on low duties.

### Water Movements in Cornish Boilers.

It is interesting to examine the water movements taking place in various types of boiler, although it has to be admitted that the exact movements under full-duty conditions are only imperfectly understood.

In the case of the Cornish boiler when heat is first applied, the water in contact with the furnace tubes will absorb the heat, and then, on account of its lowered density, will tend to rise. The colder water from the sides of the boiler will come in to take the place of the displaced warm water, and thus a circulation of the water will be created which will be as indicated by the arrows in Fig. 71.

This movement will continue until the temperature of the water has risen to the point where steam is generated. Steam bubbles will gradually be formed on the heating surface, will be displaced by the water and rise. In their passage through the water over the furnace they will assist the circulation for two reasons:—

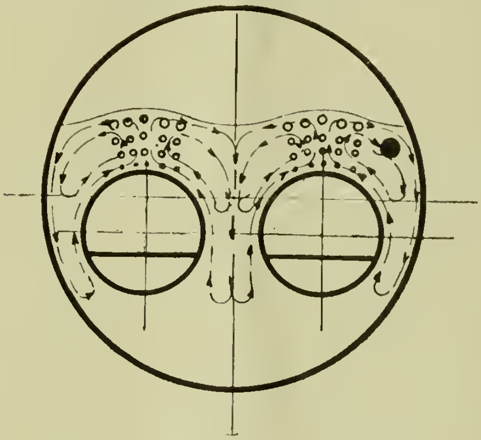

Fig. 73.—Boiler-House Efficiency.

(1) Because the density of the mixture over the furnace is now very much less than the colder feed water, and

(2) Because the rising steam bubbles have a "lifting" action on the water, apart from that caused by the lower density of the mixture.

As still more heat is applied and the volume of steam generated becomes larger, the circulation becomes more violent, and the water will take up the form and movement as shown in Fig. 72.

A consideration of these water movements in a Cornish boiler suggests the following points:—

(1) That in a boiler of this type, on account of the large water capacity, it is quite easy to quickly and completely replace the ascending water and steam by the feed water, and thus to keep the heating surfaces "wet."

(2) That even with varying steam demands the natural circulation will remain good.

(3) That the water below the furnace tube takes little or no part in the circulation and is thus comparatively cool.

(4) That the direction taken up by the convection currents is quite natural and in no way forced.

With regard to the latter point, that the convection currents are fairly free to take up any desired movement, it is certain that other currents are flowing in the boiler besides the ones shown in Fig. 72. Assuming the length of the flue to be 30 ft., it is well known that one-half of the total evaporation of the boiler takes place in the first 10 ft., in which portion the maximum effect of the furnace operates. There will be a tendency therefore for a water movement having a direction from the front to the back of the boiler over the furnaces, down the back of the boiler, and return from back to front under the furnaces. As a matter of fact, one of the patent circulators on the market has as its object the promotion of this movement. Whilst there can be no doubt that such currents are set up, still the primary circulation is as shown in Figs. 71 and 72.

### Water Circulation in Lancashire Boilers.

In the Lancashire boiler the circulation of the water will take place as indicated in Fig. 73.

In this boiler the insertion of tubes such as the Galloway tubes through the main flue will greatly assist in promoting water circulation and at the same time increases the heating surface.

*(To be continued.)*

## ALTERNATIVE FUELS FOR GAS-PRODUCER PURPOSES.

By F. R. Parsons.

### High Price of Solid Fuels.

The alarming rise in the price of solid fuels for gas-producer purposes, and its concomitant unreliability of supplies makes the question of gas-power production one of some little difficulty to-day. Up to within the last two or three years anthracite and gas coke could be procured both dependably and reasonably, in so far as price was concerned. To-day many a gas-power user has, through the reverse of this, been driven to scrap his producer plant and connect to his engines gas from the town's supply. In some instances this is the only alternative, but, on the other hand, there are numberless occasions when a fuel substitute might well be employed, and which might be obtainable, if not in the immediate neighbourhood, then at no great distance. And this refers chiefly to the use of waste products from mills and factories.

### Gas from Peat, Wood, &c.

It is not too much to say that the opinion held by the majority of gas-power users would appear to be that the use of either coal or coke is indispensible to the production of gas for power purposes. Or, perhaps, to slightly qualify this statement, that efficiency and economy is to be obtained only by the use of such fuels. But this is an erroneous impression. As a matter of fact as good a quality gas for power purposes can be obtained from peat, bark, waste wood and sawmill scrap, tannery or leather refuse, cotton seeds, coconut shells and fibre, coffee husks, or, in fact, any vegetable matter, as from the best anthracite. And in point of calorific value—the principal factor from a power-producing standpoint—good quality, air-dried wood refuse will yield a gas of much higher calorific value than will anthracite; that from the former being in the neighbourhood of 170 British thermal units per cubic foot, while the latter might not exceed 140.

### Calorific Qualities of Fuels.

Before dealing with the question of adapting an existing producer plant to suit the consumption of an alternative

fuel, it will not be amiss to first consider the relative calorific qualities of various alternative fuels, and their peculiar fitness, or otherwise, for the purpose of power-gas production. It may be said, here and now, that anything, any material, vegetable or animal, which can be consumed in the ordinary way in a furnace or generator, with or without the aid of forced draught, will give off a gas of some value, which may be turned to advantage as a power-producing medium. It may possess few illuminating elements, or, perhaps, none at all in the sense generally understood, but it may, nevertheless, be rich in calorific value. It may, per pound weight of fuel, be extremely low in combustible elements, and high in diluents, but if the supply of combustible material, whatever it may be, is unlimited in quantity, cheaply handled, and otherwise valueless as a commercial product, it only needs certain and not extensive adaptations of existing plant to make it a valuable commodity as a gas-producing medium.

### Turn Waste Materials into Gas.

For example, there must be thousands upon thousands of tons of manufacturers' refuse, of all descriptions, wasted annually, which might very well be converted into power gas. In one instance known to the writer there is a mountain of useable refuse, sawdust, borings, shavings, chips, etc., from a large sawmill and wood-working factory, which occupies a space in an adjoining field of certainly not less than a hundred yards in length, by thirty to forty in width, and is from fifteen to twenty feet in height. How many thousand cubic feet of power gas is stored there would be difficult to compute, but certain it is that the conversion of this heap into gas and power would add materially to someone's dividends.

### Wood Fuels.

Regarding the alternative use of wood fuels for gas producer purposes, the first consideration is its relative value, weight per weight, with anthracite. The combustible constituents contained in all kinds of wood fuel are practically alike in quantity, and when the fuel is air-dried, as all fuels coming under this category should be, when used in a gas producer, particularly a suction plant, and contains no more than 25 per cent of moisture, the combustible constituents would be as high as 50 per cent by weight. The calorific value of hard, air-dried wood fuel, as distinct from sawdust, might reach 7,000 British thermal units per pound; while an analysis taken by an eminent authority shows the average composition of gas from a wood-fuel producer to be: H, 12·9; CO, 27·6; $CH_4$, 2·2.

### Relative Qualities of Wood Fuels.

The following table gives the relative quantities of wood fuels to equal in calorific value the best anthracite, the latter being represented by the figure 1:

| | |
|---|---|
| Hickory, or hard maple | 2·25 |
| White oak, beech, red oak, mahogany | 2·24 |
| Poplar, chestnut, elm | 2·23 |
| Pine | 2·16 |

Deducing from the above, it would appear that approximately $2\frac{1}{4}$ lbs. of air-dried wood is equal in calorific value to 1 lb. of average quality anthracite. But as against this must be set the fact that for each pound of wood fuel consumed a gain of at least 2,000 B.Th.U's is secured.

### Adaptations to Plant.

Now let us see in what particular direction lies the adaptations to plant necessary when the use of an alternative fuel is contemplated. The first requirement will of necessity be a generator capable of dealing with the extra bulk of fuel demanded in order to supply the same amount of gas as when anthracite or gas coke is used. If the capacity of this, that is to say its cross-sectional area and cubical contents, is allowed roughly to be from $2\frac{1}{2}$ to 3 times that of a generator using anthracite, equal gas productive results should be secured. Some regard must, however, be paid to the character of the fuel proposed to be used, for this will have an important bearing upon the constructional details of the generator.

For instance, to ensure sufficient density of the fuel bed when waste pieces of wood are used its active depth must be considerably greater than if small, dense fuel, such as sawdust, wood borings or chips, are used. Then, again, the feeding hopper must be of much greater capacity and of larger cross-sectional area relatively than if coal is used, and its design will necessitate adaptation to the character of the fuel used, inasmuch as the conical-valve charging hopper being dispensed with, the aim must be to provide a chamber which, when filled with fuel, will offer a greater resistance than that in the body of the generator, otherwise air will be drawn in above the conversion zones of the fuel bed.

### About the Vaporiser.

The vaporiser, indispensable when coal or coke is the fuel used, may in many instances be dispensed with when consuming wood refuse, or, indeed, many other kinds of material in which moisture is in a great measure present. The moisture contained even in air-dried wood fuel is quite sufficient to keep down the temperature in the combustion zone of the generator, and any loss of hydrogen is balanced by the volatile gases contained in the fuel.

### The Only Trouble.

The greatest, or perhaps it would be more correct to say, the only trouble met with in the utilisation of waste wood fuel, sawdust, etc., is the elimination of the much greater proportion of tar, and the removal, at an equally early stage of the purifying process, of the dusty particles drawn out of the generator. The coke scrubber, ordinarily used in producer plants when coal or coke is the medium, is incapable of dealing effectively with these products of combustion. They need to be arrested immediately on leaving the generator. This is best done by passing the gases straight from the outlet of the generator into a centrifugal tar separator—a fan-like arrangement which, in revolving at great speed, whirls the heavier tar particles, and the dust, to the periphery of the blades, where the whole is either carried or washed away by impinging streams of water from the body of the extractor. This, and an additional wood-wool purifier, connected after the usual coke-scrubber, is, generally speaking, about all the additional plant necessary to instal when considering the use of an alternative wood fuel.

### The Question of Labour.

Naturally, the use of wood refuse, or any other fuels of this description, will involve the expenditure of slightly more attendant labour, both for handling the increased bulk of fuel, and also for seeing that the fuel bed is maintained in an efficient condition, since "hanging-up" is a possibility not by any means remote when consuming fuel of fairly large size. But as against this clinkering troubles are, as a rule, unknown in a wood-fuel generator, and its concomitant repairs to the firebrick lining, and renewals, are reduced quite considerably.

# FUEL ECONOMY.

First Report of Committee Appointed by the British Association.

At the recent meeting of the British Association at Newcastle-upon-Tyne the first report of the Committee appointed for the Investigation of Fuel Economy, the Utilisation of Coal, and Smoke Prevention was presented. The Committee consists of Prof. W. A. Bone* (chairman), Mr. E. D. Simon* (secretary), the Right Hon. Lord Allerton,* Mr. Robert Armitage, Prof. J. O. Arnold, Mr. J. A. F. Aspinall, Mr. A. H. Barker, Prof. P. P. Bedson, Sir G. T. Beilby,* Sir Hugh Bell,* Mr. E. Bury, Dr. Charles Carpenter,* Dr. Dugald Clerk,* Prof. H. B. Dixon, Dr. J. T. Dunn,* Mr. S. Z. de Ferranti, Dr. William Galloway, Prof. W. W. Haldane Gee, Prof. Thos. Gray, Mr. T. Y. Greener,* Sir Robert Hadfield,* Dr. H. S. Hele-Shaw,* Mr. D. H. Helps, Mr. Greville Jones, Mr. W. W. Lackie, Mr. Michael Longridge, Dr. J. W. Mellor, Mr. C. H. Merz,* Mr. Robert Mond,* Mr. Bernard Moore, Hon. Sir Charles Parsons,* Sir Richard Redmayne,* Prof. Ripper, Prof. L. T. O'Shea, Mr. R. P. Sloan, Dr. J. E. Stead,* Dr. A. Strahan,* Mr. C. E. Stromeyer, Mr. Benjamin Talbot, Prof. R. Threlfall, Mr. G. Blake Walker, Dr. R. V. Wheeler, Mr. B. W. Winder, Mr. W. B. Woodhouse, Prof. W. P. Wynne, Mr. H. James Yates,* and their report is as follows:—

## National Aspects of Fuel Economy.

The national aspects of fuel economy may be considered from two somewhat different standpoints, namely (1) in view of the economic situation created by the war, which will necessitate the general adoption of more scientific methods in the future development and utilisation of the nation's mineral reserves, and (2) in view of that remoter, but possibly not far distant, future when our available coal supplies will be restricted by approaching exhaustion. In approaching its task the Committee decided that it could best serve the national interest by concentrating its attention upon the more immediate aspect of the problem.

It can hardly be questioned that the chief material basis of the great industrial and commercial expansion of this country during the past century has been its abundant supplies of easily obtainable coal, which, until recent years, has given us a position of advantage over all other countries. It is also equally true that we can no longer claim any advantage in this respect over our two closest competitors.

## General Adoption of Scientific Methods Important.

There can be little doubt but that up to the present we have been wasteful and improvident in regard to our methods of getting and utilising coal, and that not only are great economies in both these directions attainable, but also that the question of the general adoption of more scientific methods in regard to these matters is one of vital importance, in view of the trying period of economic recuperation which will immediately succeed the war.

For some years before the war the average price of coal at the pithead had been decidedly on the up-grade, owing chiefly to deeper workings, higher wages, and greater precautions for ensuring the safety of the mines. The result of the great coal strike in 1912, and the legislation which it provoked, was to accentuate this tendency. And if, as seems probable, prices continue to rise for some time after the war at an accelerated rate, as compared with the pre-war period, the question of the best utilisation of fuels will be of increasing importance to the nation.

* Denotes a member of the Executive Committee.

## The World's Resources.

According to the report upon the World's Coal Resources issued by the International Geological Congress in the year 1913, the geographical distribution of the world's total possible and probable reserves of coal of all kinds available within 6,000 ft. of the surface amounts in all to 7,397,553 million metric tons. The fact that the available reserves of coal in Great Britain only amount to about one-fortieth, whilst those of the whole Empire do not amount to more than about one-fourth, of the world's estimated total, is one which ought to be brought home to everyone responsible for the economic development of our national and imperial resources, especially in view of the fact that the United States, whose competition in the immediate future will probably be much more severely felt than ever before, possess more than half the estimated world's coal, and that also in regard to the two prime considerations of quality and cost of production the States probably compare favourably with Great Britain and the Empire.

## Chemical Investigations and Trials in U.S.A.

Moreover, it may be pointed out that in the United States both the Government and the University of Illinois have, for some years past, conducted numerous important chemical investigations and large-scale trials upon the character of the principal American coal seams and their adaptation for various economic ends, and that, in consequence, American manufacturers have at their disposal much more complete and systematic information about their country's coal resources than is at present possessed by their British competitors. Also, the United States Government, which is continually extending its policy of the conservation of its natural resources, has already taken legislative steps to prevent the premature exploitation of the coalfields of Alaska. Nor has Canada lagged behind her neighbour, as is proved by the recent exhaustive "Investigation of the Coals of Canada with reference to their Economic Qualities," conducted at the McGill University, Montreal, under the authority of the Dominion Government, and published in the years 1912 and 1913 by the Department of Mines in six imposing volumes. No such comprehensive investigations have ever been undertaken in this country, where they are much needed. The Committee is of opinion that the example of the United States and Canada might be followed with advantage to the industrial community by the Government of Great Britain, and that representations should be made with the object of inducing the Government to provide adequate funds in aid of further researches and investigations upon the chemical character of the principal British coal seams, the best means for their future development in the national interest, and upon problems of fuel economy, including the utilisation of all the by-products obtainable from coal.

## The World's Demands for Coal.

The rapid increase during recent years in the world's demands for coal is shown by the following approximate

figures covering the ten years' period immediately preceding the outbreak of war:—

| | Approximate Total. Millions of Tons. |
|---|---|
| 1903 ... ... ... ... | 800 |
| 1908 ... ... ... ... | 1,000 |
| 1913 ... ... ... ... | 1,250 |

From these figures it would appear that, during the period in question, the world's demands have continuously increased at a compound interest rate of nearly 5 per cent per annum. Another important fact is that these demands have been principally met by three countries, namely, the United States, Great Britain, and Germany, which, between them, have hitherto annually raised 83 per cent of the total anthracite and bituminous coals consumed in the world. This being so, it is of interest to compare the relative rates of increase in the coal productions of these three countries during recent years, which may best be deduced from a comparison of quinquennial averages over a period of 15 years, from 1900-1914 inclusive, as in Table I.:—

Table I.—Coal Productions of the United States, Great Britain, and Germany—Quinquennial Averages. 1900 to 1914.

| Period. | Millions of tons per annum. | | |
|---|---|---|---|
| | United States. | Great Britain. | Germany.* |
| 1900–04 .... | 288·2 | 226·8 | 112·5 |
| 1905–09 .... | 400·5 | 256·0 | 139·8 |
| 1910–14 .... | 519·2 | 269·9 | 169·3 |

* Excluding lignites and brown coals.

## Coal Output in Great Britain, United States and Germany.

From these figures it may be inferred that up to the outbreak of the war the coal output of the United States was increasing annually at a compound interest rate of about 6 per cent, that of Germany at a compound rate of about 4 per cent, whilst the British output was increasing at a compound rate of 2 per cent only. During the period 1910-14 the United States produced nearly twice as much coal as Great Britain, and, assuming that these relative rates of increase are maintained after the war, it may be predicted that Germany's output of coal will overtake that of Great Britain about 20 years hence, when each country will be producing some 420,000,000 tons per annum.

## By-products from Coal.

The public cannot be too often reminded that not only is coal of prime importance as a fuel, but also that, when suitably handled by the chemist, it yields very valuable by-products, which are the raw materials of important industries. Thus from coal-tar, and other by-products of its distillation, are obtained the raw materials for the manufacture of both synthetic dyes and drugs and certain high explosives. Another important by-product obtainable is ammonia in the form of sulphate, which is chiefly used as a fertiliser in the production of foodstuffs. The use of artificial fertilisers, including ammonium sulphate, by agriculturists in Great Britain is still in its infancy, and the near future ought to see a large expansion in the home demands for nitrogenous fertilisers.

## Liquid Hydrocarbon Products.

Among other products obtainable by the low-temperature distillation of coal are liquid hydrocarbons of the paraffin and naphthene series, and it is probable that large quantities of "motor spirit" could be manufactured in this country from coal. There is no doubt that we in this country have not been sufficiently alive to the importance of recovering such by-products from the raw coal raised in our mines, and that we have been very much behind Germany in this respect. Thus, for example, whilst in the coking industry modern by-product recovery plants had been universally installed years ago throughout Germany, we were, in 1913, still carbonising about six and a half million tons of coal annually for metallurgical coke in old-fashioned beehive ovens. Also, whereas our total production of ammonium sulphate from coal was in 1913 about 318,000 tons, Germany produced nearly half a million tons from a very much smaller output of coal.

## Progress in Fuel Economy.

The community needs to be reminded that, at least so far as this country is concerned, progress in fuel economy involves something more than increased thermal efficiency in respect of power production and of heating operations generally, important as these undoubtedly are. It also involves the whole question of the better utilisation of our coal, including the recovery of by-products and the consequent abolition of the smoke nuisance, which, at present, directly and indirectly, costs the country many millions of pounds per annum.

## The Total Output of British Mines.

There are two outstanding features in the history of the British coal trade to which the Committee desires to draw attention. One is the remarkably steady increase in the total output of our mines, which, since 1870, has been maintained at an almost uniform compound interest rate of 2 per cent per annum, as Table II., giving quinquennial averages over a period of 45 years—1870-1914—shows.

TABLE II.—Coal Production in Great Britain—Quinquennial Averages 1870 to 1914—Millions of Tons per Annum.

| Period. | Average output. | Calculated at 2 per cent compound interest. | Proportion of total output exported. |
|---|---|---|---|
| 1870–74 .... | 121·5 | 121·5 | 0·13 |
| 1875–79 .... | 133·6 | 131·1 | 0·146 |
| 1880–84 .... | 156·4 | 148·1 | 0·172 |
| 1885–89 .... | 165·2 | 163·5 | 0·200 |
| 1890–94 .... | 180·3 | 180·5 | 0·220 |
| 1895–99 .... | 202·0 | 199·3 | 0·237 |
| 1900–04 .... | 226·8 | 220·1 | 0·27 |
| 1905–09 .... | 256·0 | 243·0 | 0·31 |
| 1910–14 .... | 269·9 | 268·2 | 0·326 |

The second feature is the phenomenal growth of our export trade, which, during the past 60 years, has increased something like 20-fold, both as regards the quantities and the values of coal exported. Moreover, its value relative to other values exported has, during the same period, increased fourfold, until at the outbreak of war it constituted about 10 per cent of our total exported values. We were then actually transacting over 70 per cent of the total sea-borne coal trade of the world. It

must, however, be borne in mind that a considerable proportion of the exported coal supplies the needs of our mercantile marine.

Another circumstance which demands attention is the fact that the proportion of the coal raised annual in the United Kingdom which is exported has been doubled within the past 35 years, trebled within half a century, and is still increasing. Three factors have operated in producing this result. One is the proximity of the finest coalfields to our ports, another is the increased demands for coal from Europe and South America, while a third has been the phenomenal growth of our mercantile marine.

*(To be continued.)*

# New Companies Registered.

FARADAY AND SON LTD. (114,736).—Private company. Registered August 31st. Capital, £5,000, £1 shares. Agreement with Rosa B. Faraday, P. Faraday, and L. B. Faraday, to carry on the business of electrical engineers and manufacturers of electrical fittings as formerly carried on by the said vendors at 146-150, Wardour Street, W., as "Faraday and Son." Directors: P. Faraday and L. B. Faraday (both permanent, special qualification one share). Qualification of ordinary directors, 500 shares. Solicitors: Redpath, Marshall, and Holdsworth, 23, Bush Lane, E.C.

C. S. HOOK AND CO. LTD (144,815).—Private company. Registered September 9th. Capital, £4,000, £1 shares (2,000 "A" and 2,000 "B"). Engineers, manufacturers, and suppliers of and dealers in power, transmission, factory, or works equipment, etc. Solicitors: Pakeman, Son, and Read, 11, Ironmonger Lane, E.C.

INSULATED CAP AND RIVET CO. LTD. (144,808).—Private company. Registered September 8th. Capital, £5,000, £1 shares. Engineers, founders, smiths, machinists, manufacturers, and patentees of caps for electric lamps and rivets for all purposes, etc. Directors: W. L. T. Arkwright and W. F. Mohr (provisional directors). Qualification of subsequent directors, £100. Registered office: Caxton House, Westminster.

"K. and C." ENGINEERS' SUPPLY CO. LTD. (144,784).—Private company. Registered September 6th. Capital, £3,000, £1 shares. Manufacturers of and dealers in new and second hand tools, machinery, iron, steel and metals, and general engineers' requisites, etc. Directors: H. Katzner and P. W. Cordingley. Qualification, 500 shares. Registered office: 110, City Road, E.C.

STOCKFIELD WORKS LTD. (144,786).—Private company. Registered September 6th. Capital, £2,000, £1 shares. To take over the business of a general engineer and mechanic carried on by A. E. Taylor at Stockfield Road, Acocks Green, Birmingham, as "Taylor Brothers." Registered office: Stockfield Garage, Stockfield Road, Acocks Green, Birmingham.

TAIG MOTOR AND ENGINEERING CO LTD. (144,812).—Private company. Registered September 8th. Capital, £1,500, £1 shares. As title. Agreement between D. H. Torrance, R. Taig, and the Taig Motor and Engineering Co. Ltd. Directors: D. H. Torrance and R. Taig. Qualification, 50 shares. Secretary, R. Taig. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

W. R. THORNTON AND SON LTD. (144,787).—Private company. Registered September 6th. Capital, £5,000, £1 shares. To take over the business of engineers' furnishers and electrical engineers and contractors for and dealers in mechanical and electrical apparatus and appliances carried on by the executors of W. R. Thornton, of Barrow-in-Furness, as "W. R. Thornton and Son." Directors: W. R. Thornton (permanent managing director, subject to holding 50 shares) and A. Haynes. Qualification of directors, £100. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

VALVE GUIDES LTD. (144,836).—Private company Registered September 12th. Capital, £2,000, £1 shares. Manufacturers of valve guides and other parts of engines, engineers, founders, smiths, machinists, etc. Registered office: Crown Works, Cricklewood Lane, N.W.

# Trade Items, Notes, &c.

Chrome-vanadium steel has the great advantage that it is easily and rapidly machined, even with an elastic limit of 60 tons per square inch.

A total of 28 Heroult electric furnaces for steelmaking were licensed in the United States and Canada during the first half of 1916. At present 72 are in operation, are in the course of building, or have been authorised.

From the beginning of the war the German mining industry has been very seriously handicapped by shortage of labour, and female labour is being exploited on an increasing scale. It is now stated that the number of female hands employed in the mining industry of Germany amounts to 45,500, against 5,500 at the beginning of the war.

Lead-plated Steel.—A new process has, says "The Iron Age," been developed which will render possible the substitution of lead-plated steel for zinc and nickel-plated material, and phosphor-bronze, copper, and brass parts used where metal needs protection from corrosion caused by acids, salts, and fumes.

American Petroleum.—The quantity of petroleum marketed in the United States in 1915 was 281,104,104 barrels, valued at 179,462,890 dollars. There was more American crude petroleum marketed last year than in any previous twelve months in the history of the industry. The increase over 1914 was nearly 6 per cent.

Saving Oil Fuel.—We are told that at a British military depôt "somewhere in France," all the waste lubricating oil, and dirty paraffin that has been used for cleaning engines, is mixed together to form a fuel that is used in the oil-fired melting furnaces in the foundry. By so doing, it has been found possible to eliminate fuel-oil requisitions altogether, excellent results being obtained from a substitute that, since it is a waste product, costs the country nothing.

It is announced by the Board of Trade that, in agreement with the British Government, the French Government has just set up at King's House, Kingsway, London, W.C., a special office for the issue of licences for the importation into France and Algeria of goods of British production or manufacture which are included in the list of articles prohibited to be imported into those countries.

Rich Iron Ore Deposits.—According to a Valparaiso journal, of the rich iron ores, graded at over 60 per cent, the world's stock is estimated to be 2,521,000,000 tons. From this total must be eliminated 1,095,000,000 tons from Sweden (on account of the prohibition of export of pure ores) and 400,000,000 tons from Brazil (principally from the State of Minas Geraes).

When removing enamel from wire, many users scrape the enamel from the copper wire with emery cloth or sandpaper. In doing this it is almost impossible to keep from removing some of the copper. If only 0.0001 in. is removed, it will show on a micrometer caliper or wire gauge. There are two ways of removing the enamel: one of these is to pass the wire over a bunsen gas flame several times until the enamel melts and drops off; the other is to dissolve it in amyl alcohol.

The Factory Department of the Home Office announce that on and after October 4th it will not be necessary for the occupier of a factory or workshop to notify any accident to the certifying surgeon. Accidents must still be notified as before on Form 43, to the District Inspector of Factories, and entered in the General Register. The certifying surgeon may be required by the inspector to report upon certain accidents, and for this purpose will have the same powers as in the past.

It is said that the whole of the American Navy is shortly to be armed with a new type of anti-aircraft gun possessing novel features. The diameter of the bore is reported to be 3 in., and the length about 50 calibres. This gun is credited with being able to throw projectiles at a rapid rate to a height of 27,000 ft. when pointing vertically. It is understood that each vessel is to carry two of these guns, mounted in such a way that they may be fired in all directions.

CORK substitutes, according to a suspended German application for a patent, in the process of making artificial cork objects from granulated cork mixed with a soluble binding substance and heated under pressure in moulds, a vacuum is produced in the closed chamber containing the moulds during the heating. The heating, which may be effected by steam pipes, is preferably gradual, and rises in five or six days to a maximum of 70 deg. to 80 deg. Cen. A solution of casein may be used as the binder and formaldehyde for hardening the material when removed from the mould.

COAL, a recent discovery, is now one of the commercial products of the Federated Malay States. It is being mined in Selangor, not far from Kuala Lumpur, by the Malayan Collieries Ltd. Though work on an extensive scale was not begun till September last, 11,523 tons of coal were raised in 1915, and it is stated by Mr. W. Eyre Kenny, Senior Warden of Mines, that this coal, where used in suitable plant, will exercise an important influence on mining and other costs, and it is hoped will tend to reduce the consumption of firewood. Among other consumers, two large mines have taken the coal into use, a considerable saving in working expenses having resulted, and a contract has been entered into for part supply of the F.M.S. Railways.

STANDARD TABLES FOR PETROLEUM OILS.—Samples of petroleum oils have been collected from different parts of the country by the United States Bureau of Standards, and the specific gravity determined over a wide range of temperature. From the data obtained tables have been prepared for determining the true specific gravity and volume of oil at the standard temperature, when these quantities are measured at other temperatures. Tables have also been prepared for showing the relation between specific gravity, Baumé degrees, and pounds per gallon. The new tables will be especially useful in determining the quantity of oil in large shipments. These will very largely supersede the privately issued oil tables heretofore used. Circular No. 57 of the Bureau of Standards presents the results of these experiments, and copies may be obtained by interested persons from that Bureau at Washington.

SELF-LUMINOUS PAINTS.—Self-luminous paints consist of a mixture of an alkali sulphide (zinc sulphide is commonly used) with a small amount of radio-active material which excites the sulphide, producing a continuous glow. According to a contribution by W. S. Andrews in the *General Electric Review* the initial brightness depends on the proportion of radium; a higher percentage of this element increases the luminosity, but shortens the life of the paint by a corresponding amount. The United States Government specifies that paint used by the army and navy should maintain its luminosity undiminished for two years. Meso-thorium, a by-product of incandescent mantle manufacture, is sometimes mixed with the radium element on account of its comparative cheapness, but opinion differs as to the comparative value of paints so treated and those containing radium only.

BULGING OF FRONT FLUE SHEETS OF LOCOMOTIVE BOILERS.—A committee of the Master Boiler Makers' Association, reporting at its recent annual convention, gave an account of a test conducted for the purpose of determining the cause and nature of the bulging of front flue sheets in locomotive boilers. By using hand rollers in setting 2-in. flues in a ½-in. sheet each hole was stretched ·007 of an inch. With the self-feeding roller and hand pin the holes stretched ·029 of an inch. With the self-feeding roller and air motor the holes stretched ·021 of an inch. On the basis of a flue head having 400 holes in it, the hand rolls would stretch the holes 400 times ·007, which equals 2·8 in. The second operation—that is, self-feeding rolls and hand pin—would stretch the holes ·029 of an inch, or 400 times, which equals 11·6 in. The third operation of self-feeding rolls and air motor would stretch 400 holes a total of 8·4 in. The amount of excess material is distributed over the space worked upon in each case. As the bridges between the flues do not upset proportionately to the increase in the sizes of the holes to do the stretching of the material at certain points, each individual hole must take care of a portion of the material round it, thus making the bulging of the sheet a local condition. From the above the committee regarded it as plain that the amount of work and the tools used, as well as the experience of the man putting in the flue, governs the bulging of the sheet.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

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BERRIMAN, A. E.: Cylinder construction. 12,780.
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**1915.**

8,334—Breslauer: Dynamo-electric power-transmission.
8,335—Morison: Steam-condensing plant.
11,405—White: Conveying-devices.
12,620 and 12,621—Torrens: Carburettors.
12,714—Leyshon: Stop-cocks.
12,723—Serex: Valve-gear.
12,810—Dey: Controllers for electric motors.
12,829—Parry: Cleaning smoke tubes.
12,831—Umpleby: Valves.
12,875—Kopf: Priming devices.
13,012—Arthur G. Enock & Co., & Enock: Stuffing-box.
13,020—Liverpool Patents Co., & Clegg: Apparatus for "scaling," cleaning, or similarly acting upon surfaces.
13,278—Kingston: Synchronising rotary movements.
13,283—Dufty: Dynamo-electrical machines.
13,687—Chantrill & Haskins: Low-water safety apparatus for boilers.
14,116—Aichele: Change-gears.
14,639—Mather & Platt Ltd., & Davidson: Charging of two-cycle gas engines.
15,023—Longworth & Co., & Shaw: Hackling-machines for flax.
15,038—Brown: Controlling friction-clutches.
15,722—Langdon: Clutch and reversing-gear.
15,864—Downie: Taps or valves.
17,190—Marks: Clutch mechanisms.
17,318—Travis, & National Gas Engine Co.: Gas engines.
17,731—Ogden: Warming feed water of fuel-economisers.
17,994—Robertson & Moss: Two-stroke-cycle internal-combustion engines.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

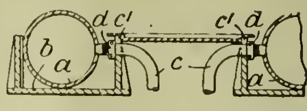
**1916.**

412—Bosch, R. (Firm of): Starting internal-combustion engines. **100,017.**
840—Ellehammer, J. C. Hansen-: Explosion motors. **101,357.**
2,149—McLaren, W. D., and Welsh, G. M.: Pump cylinders. **101,368.**
2,390—Saurer, A. (Firm of): Circulating lubricating system. **100,345.**
2,746—Clench, E. C. S.: Cylinders for explosion engines. **101,370.**
2,792—Hough, A.: Condensers. **101,307.**
3,147—Ryder, A.: Engine indicating-apparatus. **101,373.**
3,148—Ryder, A.: Engine indicating-appartus. **101,374.**
4,562—Linden, L.: Apparatus for softening water. **101,314.**
4,908—Massey, G.: Hydraulic elevators. **100,308.**
4,931—Wery, E.: Internal-combustion engines. **101,382.**
4,933—Weger, C. J.: Internal-combustion engines. **101,383.**
5,350—Norma Cie: Antifriction bearings. **100,277.**
5,391—Allmanna Svenska Elektriska Aktiebolaget: Dynamo-electric generators. **100,394.**
5,474—Jones, H. Sefton-: Antifriction bearings. **101,388.**
5,992—Bugatti, E.: Internal-combustion engines. **101,390.**
6,345—Black, S. D., and Decker, A. G.: Air compressors. **100,635.**
6,354—Lozinski, C.: Internal-combustion engines. **101,392.**
7,451—Travell, W.: Hoisting and transporting mechanism. **101,396.**
9,811—Schmidt'sche Heissdampf Ges.: Superheaters. **101,145.**
9,937—Breslauer, M.: Dynamo-electric power-transmission apparatus. **100,894.**

## ABSTRACTS OF SPECIFICATIONS.

### STEAM SUPERHEATERS.

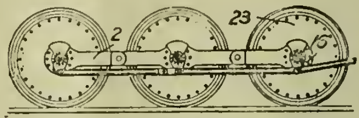
100,903.—J. Gordon, Canada House, Kingsway, London.—March 7th, 1916. No. 3,393.—Superheating tubes are connected to their headers by means of nuts screwed on the ends of the tubes and adapted to bear against brackets secured to, or gripping upon, the headers. The nuts $d$ on the ends of the loop-tube $c$ bear

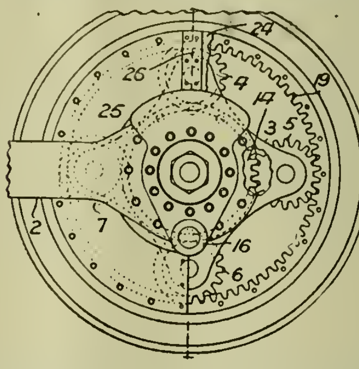



against the sides of the carriers $b$ and force the tapering tube ends into holes in the headers $a$. The sides of the carriers are formed with notches $c1$ to receive the tubes. In modifications, brackets riveted to the headers or held in position by rings around the headers are used in place of the carriers.

### DRIVING-GEAR FOR LOCOMOTIVES.

100,904.—M. L. Davis, Oak Grove, Alabama, U.S.A.—March 29th, 1916, No. 4,614.—Driving-gears for locomotives are formed with internal teeth 19 with which mesh pinions 4 . . 7 carried by a spider 3 and driven by a wheel 14 operated by the crank 16. The

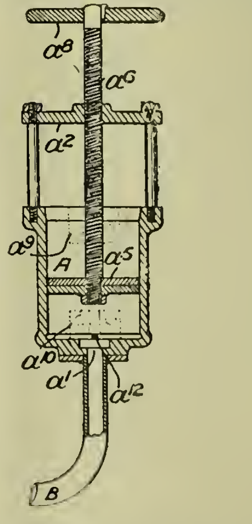



spider 3 is prevented from rotating by being bolted to bars 2, Fig. 1, which are hinged together between the wheels. In order that the parts may work in oil, a covering member is provided which comprises two semi-annular plates 24, 25 connected together by overlapping strips 26.

### LUBRICATORS.

100,909.—E. K. Wallace and J. L. Wallace, 60, St. Enoch Square, Glasgow.—May 13th, 1916, No. 6845.—A lubricator for forcing grease or solid lubricant to the stern tubes of ships' propeller shafts,

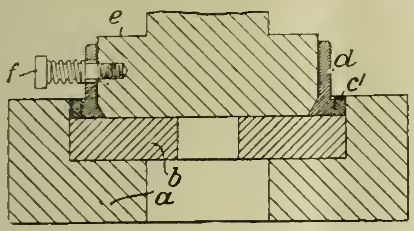



etc., comprises a flat-bottomed open-mouthed cylinder A containing a piston $a5$ with metallic packing and operated by a hand-wheel $a8$ on a screwed rod $a6$ engaging a cross-head $a2$. The cylinder has integral lugs $a9$, $a10$ for attachment to a bulkhead. The lubricant is forced through a large central opening $a1$

to a pipe B, which may connect with valved branch pipes leading to the parts to be lubricated. An air cock $a12$ is provided near the base of the cylinder.

## PISTONS.

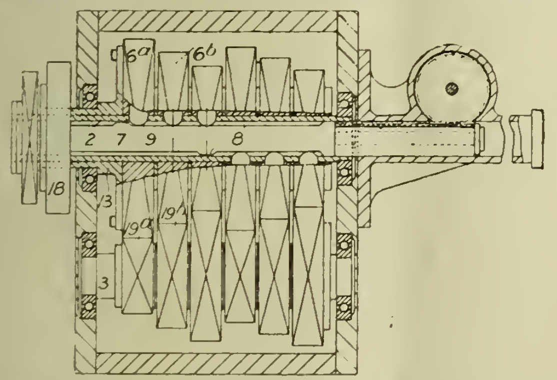
100,907.—R. Allen, "Lynwood," Kidmore Road, Caversham, Oxfordshire.—April 7th, 1916, No. 5,149.—Packing-rings of the Ramsbottom type, or of the type used in the Gnome engine, are simultaueously pressed to shape and peened by means of a hammer or press. The packing-ring $c1$ is placed in a die $a$ and is acted on by a hammer ring $d$, which may be formed, as shown, with teeth acting as hammer faces. The hammer ring




is split or formed in sections, and is expanded by the descent of the top, $e$, to which it may be connected by means of studs $f$, as shown. The axis of the tup is preferably eccentric to the die, in order that the packing-ring may be more highly compressed at the part remote from the split. A guiding projection on the tup may enter the central hole in the plate $b$ which is employed to lift the ring out of the die.

## VARIABLE-SPEED GEARING.

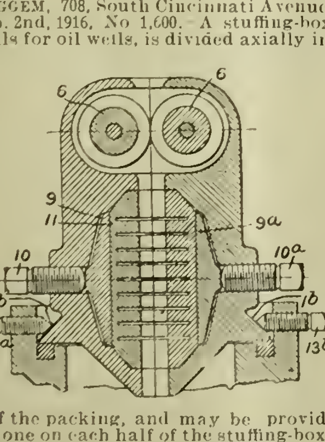
100,912.—D. E. Davies, Queen Anne's Chambers, Tothill Street, Westminster.—June 6th, 1916, No. 7,988.—In variable-speed gearing for motor-vehicles, etc., of the kind having a series of change-wheels adapted to be coupled singly to a shaft by expanding-ring friction clutches operated by a cam sliding longitudinally in or on the shaft, two or more cams are arranged in different radial planes and are so spaced apart that one only is in operation at the same time. Each cam controls a number of change-wheels




and comes into operation in cyclic order. The cams 7, 8 are formed on a sliding member 9 which rotates with the driving shaft 2. The wheels $6a$, $6b$, etc., are in constant mesh with wheels $19a$, $19b$, etc., fixed to a countershaft 3. The wheel $6a$ is fixed to a driven sleeve 13 carrying a wheel 18, so that the shaft 2 can drive the sleeve 13 either directly through the wheel $6a$ or indirecty through a pair of the change-wheels $6a$, $19a$, etc. In a modification, the cams 7, 8 are formed on separate keys sliding in slots in a solid shaft 2.

## STUFFING-BOXES.

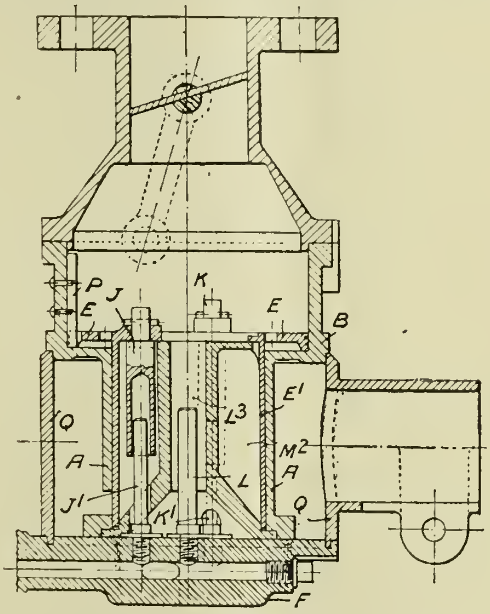
100,927. A. G. Heggem, 708, South Cincinnati Avenue, Tulsa, Oklahoma, U.S.A. Feb. 2nd, 1916, No 1,600. A stuffing-box, particularly applicable for drills for oil wells, is divided axially in order to facili-




tate the renewal of the packing, and may be provided with guide-rollers 6, mounted one on each half of the stuffing-box and preferably grooved. The rubber or other packing-sleeve 11 is also divided axially, and is preferably formed with grooves, which may be filled with lubricant, copper, Babbitt-metal, or wood fibre, etc. The packing-sleeve has bevelled ends, is contained in a chamber in the stuffing-box formed with bevelled ends, and is set up towards the rod by followers 9, $9a$ adjusted by screws 10, $10a$. The stuffing-box may secured on its seating by means of screws $13a$, $13b$ engaging a bevelled flange $1b$ on the box.

## INTERNAL-COMBUSTION ENGINES.

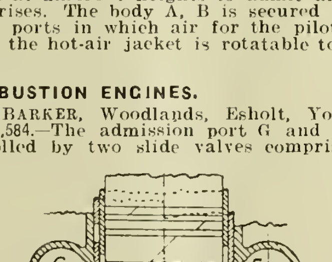
100,924.—F. F. Stratton, Oak Lodge, Park Hill Road, East Croydon, Surrey.—Jan. 13th, 1916, No. 578.—A number of fuel nozzles are brought into action in succession by caps suspended from a suction-actuated air-controlling valve of the kind described in Specification 8,492/14. The valve, of two diameters E1, E slides in the carburettor body A, B and carries caps J, K, etc., which are of different lengths and fit loosely over, and bring into action in succession the nozzles J1, K1, etc. A central uncontrolled pilot




nozzle L is situated in a choke-tube L3 of considerable length, the other nozzles being situated in chambers formed by partitions M2, etc., radiating from the choke-tube L3, the valve E1 being slotted to pass over these partitions. The valve is prevented from rotating by strips P and, at its lower end, is provided with ports at different heights to admit air to the nozzle chambers as it rises. The body A, B is secured by bolts to the base F, through ports in which air for the pilot nozzle enters. The casing Q of the hot-air jacket is rotatable to facilitate connecting-up.

## INTERNAL-COMBUSTION ENGINES.

100,977.—T. N. Barker, Woodlands, Esholt, Yorkshire. March 10th, 1916, No. 3,584.—The admission port G and exhaust port F are each controlled by two slide valves comprising one whole

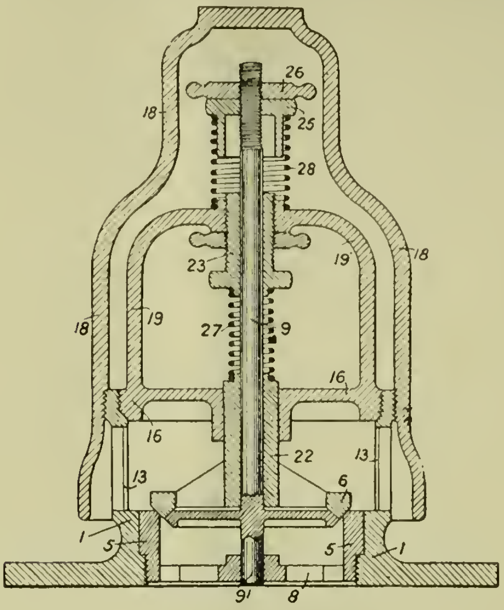



cylinder D and two semi-cylinders or segments B, C. The valves are driven from two shafts by linkage gear so that they move in opposite directions in opening and closing the ports. The shafts are driven by a single chain

## SAFETY-VALVES.

100,928. F. M. Timpson, 4, Coventry Road, Ilford, Essex, and A. O. Robertson, 68, Hearnville Road, Balham, London.—Feb. 8th, 1916, No. 1,859. A combined pressure and vacuum relief valve, of the type in which the pressure-relief valve member carries the seat for the vacuum-relief valve member, has the loading-springs so arranged that they are out of contact with the controlled fluid and may be adjusted without removing the valves

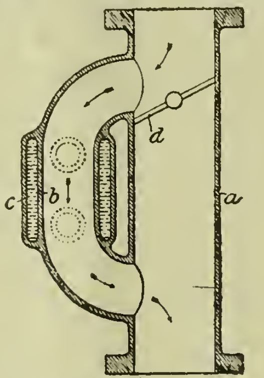
from their casing. The pressure-relief valve member 6 contacts with a removable seat 5 screwed into the casing 1, and has a tubular guide-stem 22 adapted to work through an aperture in a plate 16 screwed to the top of the valve chamber. The vacuum-relief valve is guided by a tail-piece 91 engaging a grid 8 formed on the valve seat, and by a spindle 9 passing through the stem 22 and through an adjusting-screw 23 in a bridge-piece




19 carried by the plate 16. The pressure valve is loaded by a spring 27 arranged between the screw 23 and stem 22, while the vacuum valve is loaded by a spring 28 arranged between the bridge 19 and a pair of nuts 25, 26 on the valve spindle 9. The outlet apertures are protected by gauge discs 13, and the whole device is covered by a cover 18 screwed on to the outside of the valve chamber.

### INTERNAL-COMBUSTION ENGINES.

100,991.—C. F. L. King, 122, Alma Street, Birmingham.—May 8th 1916, No. 6,560.—Liquid fuel is vaporised in a coiled pipe or chamber *c* surrounding a branch *b* from the exhaust pipe *a*. The




branch is of smaller diameter than the pipe, so that when the valve *d* is closed, back-pressure may occur in the exhaust pipe, which sends a greater stream of hot gas through the jacket of the induction pipe. The valve *d* may be controlled by a thermostat.

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U.S. Exports of Aeroplanes.—American aeroplane exports for the fiscal year ended June 30th, 1916, were 269, against 152 to June 30th, 1915, and only 34 to June 30th, 1914. The value of the exports of aeroplane parts for the fiscal year ended June 30th was about £1,000,000.

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A 30-in. belt conveyor can deal with about 270 tons of fine coal per hour when worked at its economic speed for that material. Such a conveyor, elevating the coal 20 ft., and distributing it by means of an automatic travelling tripper over a storage bunker 50 ft. long, would require 13½ H.P. to operate it, namely, 5½ H.P. for the horizontal travel, 5½ H.P. for elevating the fuel, and about 2¼ H.P. for actuating the tripper. Depreciation is rather heavy in this form of conveyor, owing to the hardening of the rubber and loss of resiliency.

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THE

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# EDITORIAL.

## ENGINEERS AND AFTER-THE-WAR PROBLEMS.

IN a recent issue of this journal we referred to questions which would arise after the war as between engineering employers and employees as regards the reversion or otherwise to the conditions prevailing in pre-war days, and expressed the opinion that the whole conditions were at present undergoing a change, and that it would be necessary to scrap many of the methods in existence before the war in the interests of employers and employed alike, as well as of the nation in general. The eyes of both sides have been opened to the question of outside competition, and of Germany and the United States in particular, whilst nationally it has been shown that engineers are capable of great efforts when placed in a tight corner.

### The Manchester Association of Engineers.

We are glad to see that the matter was taken up at the opening meeting of the winter session of the Manchester Association of Engineers by the president, Mr. F. W. Reed, who after reviewing some of the economic problems of the engineering industry in the light of the war referred to the preparations which so many countries were at present making to cope with competition after the war. As was to be expected, he also dealt with the changes which had been made to adopt machinery to munition making, and the re-organisation that would be required on the conclusion of peace to establish something like normal conditions.

### Dilution of Labour.

Some of the great problems, in Mr. Reed's view, that would have to be tackled would be that of the dilution of labour and the restriction of output. In our view it will be utterly impossible to revert entirely to pre-war conditions as regards these matters. Many trade union restrictions will have to be withdrawn, or, in the interests of both sides, never be allowed to come into force again. This is not by any means to advocate that engineering trade unions should be forcibly ignored and employers be allowed to have all their own way, but rather to indicate that there are some restrictions which existed in the past that it would be well not to revive. Restriction of output is entirely wrong in principle, and is up against inventive ideas in particular. Surely it should be a matter of pride for engineers to see that machinery is allowed to produce all that it is capable of doing, but, on the other hand, the welfare of employees should not be neglected. Each side has got to put itself in the position of the other. On the one hand it is not good for the country that labour should be unremunerative—*i.e.*, either at small wages or unemployed, nor good for the country that the output of machinery should be restricted. To restrict machinery output is to stifle invention, and this way lies national decadence. To encourage output is to stimulate further enterprise and the exercise of the inventive faculty, which is the foundation of a nation's commercial greatness. It is in this way that both German and American competition will have to be met, at any rate as regards the particular factors dealt with. Surely it is not beyond the wit of skilled engineers of both schools to devise means for an amicable and lasting agreement. As Mr. Reed rightly says: "Our future success depends on getting the utmost out of our industrial equipment. The idea of there only being a certain amount of work to do, and the less any individual did the more there would be for others, was economically bad, and to follow it up was to traverse the high road to unemployment. The great amount of capital outlay expended in equipping an engineering works formed an important proportion of the standing charges; therefore the obvious policy was to obtain the maximum output per machine, even to the extent of keeping the more important ones running night and day, and to encourage the workers' endeavours. A scheme of rewarding individual effort was advisable." There is much wisdom in this last sentence if it is not carried to the danger point of slave-driving conditions, for everyone knows that no two men are alike in their productive capacity, although each may be equally doing his best.

# VACUUM IN STEAM ENGINES.

By Edward Ingham.

## Improving the Vacuum.

The importance of reducing to a minimum the back pressure on the piston of the low-pressure cylinder of a steam engine is realised by all who have to do with steam plant. Engineers in charge of steam engines are particularly alive to this, as is evidenced by the fact that, after indicating the low-pressure cylinder, the first thing they generally do is to measure from the diagram the vacuum in the cylinder. Indeed, at one time, the skill of an engineer-in-charge was judged to a large extent by the vacuum he was able to obtain.

Whilst this question of vacuum is thus generally regarded as a most important one, very few realise the extent of the saving in £ s. d. which may often be effected by making an improvement in the vacuum.

## In a Triple-expansion Cotton Mill Engine.

Consider the case of a modern triple-expansion engine as used for driving a large cotton mill. Suppose the diameter of the low-pressure cylinder to be 56 in., and the stroke 4 ft. 9 in., speed of engine 70 revolutions per minute. Now let us see what monetary saving could be effected by improving the vacuum in the condenser and the condensing cylinder by, say, 2 lbs. per square inch, or, in other words, by reducing the back pressure on each square inch of the piston's area by 2 lbs.

$$\text{Area of piston} = \frac{\pi}{4} \times 56 \times 56 = 2{,}463 \text{ sqare inches.}$$

The actual area will be rather less than this, owing to the space occupied by the piston rod on one side of the piston. If we assume the rod to be 6 in. diameter, the mean effective piston area will be

$$2{,}463 - \frac{\frac{\pi}{4} \times 6^2}{2} = 2{,}463 - \frac{28}{2} = 2{,}449,$$

or, say, 2,450 square inches.

Owing to the reduction in the back pressure of 2 lbs. per square inch, the amount of negative work done in forcing the steam out of the cylinder each stroke is reduced to the extent of $2{,}450 \times 2 \times 4{\cdot}75$ foot pounds. Reduction per minute = $2{,}450 \times 2 \times 4{\cdot}75 \times 2 \times 70$ foot pounds. One horse power is equal to 33,000 foot pounds of work per minute. Hence,

$$\text{Saving in horse power} = \frac{2{,}450 \times 2 \times 4{\cdot}75 \times 2 \times 70}{33{,}000} = 98{\cdot}8.$$

A good triple-expansion condensing engine will use about 14 lbs. of steam per I.H.P. per hour, and if we assume that each pound of coal burned in the boilers evaporates 7 lbs. of water into steam at the required pressure, we see that approximately 2 lbs. of coal are required per hour per I.H.P. developed by the engines.

Since, by improving the vacuum by 2 lbs. per square inch, a saving of 98·8 horse power is made, it follows that $98{\cdot}8 \times 2$, or, say, 198 lbs. of coal per hour, are saved. In a week of 56 hours, the coal saving will therefore be

$$\frac{198 \times 56}{2{,}240} = 4{\cdot}95, \text{ or say 5 tons per week.}$$

Taking the price of coal to be 15s. per ton, the monetary saving will amount to 75s. per week.

This calculation shows very forcibly that where large steam engines are concerned an improvement in the vacuum will result in a very considerable reduction in the coal bill, and even with small engines very useful savings may be made.

It may be objected that the actual saving will not be so great as is represented by the foregoing calculation, because by reducing the vacuum in a jet-condensing engine, the amount of injection water flowing into the condenser will be increased, and, in consequence, more work will be thrown upon the air pump. The extra work thrown upon the pump is, however, not of importance and may indeed be left out of the question.

## Degree of Vacuum Obtainable.

The degree of vacuum which may be obtained in any particular case will, of course, depend largely on the design of the condensing plant; the most skilful engineer cannot obtain a good vacuum with inferior condensing arrangements. Given a well-designed plant, a good engineer will generally be able to work his engines with a back pressure not exceeding 1½ lbs. to 2 lbs. per square inch, but in a great many cases the back pressure is often as much as 5 lbs. or 6 lbs., when, as a matter of fact, it might easily be reduced by giving attention to small details.

## Common Causes of Bad Vacuum.

For instance, one of the most common causes of bad vacuum is leakage of air into the condenser or the condensing cylinder, and by detecting such leakages and making them good, the back pressure may often be reduced, or the vacuum increased, by a pound or two.

Other common causes of bad vacuum are leaky low-pressure pistons and valves (which allow the steam to pass on to the exhaust side of the piston, thus increasing the back pressure), defective condition of the air pump valves, etc. The engineer who is anxious to obtain the best vacuum will make a point of testing the piston and the valves at intervals so that any leakage may be discovered and made good.

It is thus seen that in a great many cases much may be done by the engineer to improve the vacuum of an engine, and in view of the important savings in fuel which can be made in this direction, it is the duty of every engineer-in-charge to be constantly on the lookout for air leakages, leaky pistons and valves, defective condition of the air pump valves, etc. Air leakages may often be detected by the aid of a lighted candle passed all over the injection pipes, the condenser, etc., but perhaps a more certain method is to subject the parts concerned to a slight hydraulic or steam pressure, when any leakages may be seen by the eye.

## Indicator Diagrams Furnish Useful Information.

Reliable indicator diagrams will, of course, often furnish valuable information as to whether or not there are any defects which may give rise to impaired vacuum. For instance, if there should be leakage of air past the low-pressure piston-rod glands, the exhaust line from the front end diagram will not be so much below the atmospheric line as the corresponding line for the back end diagram, because the air, unless there be a tail rod, only leaks through on to the front side of the piston. The difference in the diagrams may, however, be due to other causes, so that it must not be at once concluded that the fault is due to leakage of air past the piston rod. Leakage of steam past the piston rod may also in many cases be

detected by comparing the expansion line of the diagram with the true curve of expansion, which would, of course, have to be constructed on the diagram.

### Bad Vacuum Traceable to Valves.

Many instances of bad vacuum are due to improper design and setting of the valve, restricted port openings, etc. Thus, if the exhaust opening is late, the steam cannot escape freely from the cylinder, and the back pressure is in consequence high throughout a greater or lesser portion of the stroke, gradually becoming less towards the end of the stroke. In slide valve engines it occasionally happens that, owing to the exhaust port being too narrow, the opening becomes unduly restricted towards the end of the valve stroke, due to the valves moving over it, the result being that the back pressure rises considerably at about the middle of the piston stroke. This, of course, might be remedied to some extent by chipping away, when practicable, some of the metal at the exhaust port edges so as to increase the opening.

### Insufficient Supply of Injection Water.

One more cause of poor vacuum may be referred to, viz., insufficient supply of injection water. When the supply is restricted, the temperature of the water becomes unduly high, and it is then quite impossible to obtain a good vacuum. The degree of vacuum is, of course, limited by the temperature of the hot-well water. It is well known that the boiling point of water depends on the surrounding pressure. Thus, water under a pressure of 3 lbs. per square inch boils at a temperature of 142 deg. Fah., from which it follows that, unless the hot-well water be less than 142 deg., it will be impossible to obtain a less pressure in the condenser than 3 lbs. per square inch. With a hot-well temperature of only 102 deg., it is possible to reduce the pressure in the condenser to 1 lb. per square inch.

It will thus be seen that so far as the question of vacuum is concerned, it is advisable to have a large supply of injection water available, so that the hot-well temperature can be kept low. On the other hand, since the hot-well water is used for feeding the boilers, it is desirable to have as high a temperature as practicable. In practice, therefore, it is necessary to make a compromise, and it is usual to aim at a hot-well temperature of between 110 and 120 deg. Fah. Should the temperature rise beyond the latter figure, the quantity of injection water should be increased.

### More Difficult to Obtain Good Vacuum in Summer than Winter.

It will be understood that it is more difficult to obtain a good vacuum in summer than in winter, particularly if the cooling lodge is of small capacity, owing to the rise in the temperature of the water in the lodge. As a rule, the temperature of the lodge water should not be allowed to rise beyond 90 deg. Fah. Naturally, the temperature will become greater towards the end of the week, and in hot weather it is not uncommon for it to become as high as 115 deg. or even higher by noon on Saturday.

The capacity of the lodge is commonly made equal to the total quantity of water passed through the engine per day. When the capacity is insufficient to keep the temperature of the water down to the degree desired, some artificial cooling arrangement will be found of great service.

### Overstepping the Mark.

Whilst it is important in almost all cases to obtain a good vacuum in an engine, it should be mentioned that one may overstep the mark in endeavouring to attain this object. So far as a reciprocating engine is concerned, a vacuum of 13 lbs. per square inch may be regarded as very satisfactory, and, speaking generally, there is little to be gained by trying to go beyond this figure.

To gain full benefit from a very high vacuum would necessitate the use of unduly large low-pressure cylinders, and the savings effected would not compensate for the increased initial cost of the plant. With a steam turbine, the case is different, because this motor is particularly adapted for utilising the energy in steam of very low pressures, and a vacuum of 14 lbs. per square inch may generally be obtained without any difficulty. It is indeed possible to obtain higher vacuum even than this in turbine plant, but this involves extra capital cost, whilst the extra power required by the auxiliaries, and particularly by the circulating pump, becomes an important item, and hence even with turbine plant it is not advisable to attempt too much.

So far as the engineer in charge of either reciprocating engines or steam turbines is concerned, it is a good general rule to work so as to obtain the highest vacuum possible with the plant at his disposal. In most cases nowadays, the design of condensing plant is such that extremely high vacua cannot be obtained.

## THE USE OF POWDERED COAL IN METALLURGICAL PROCESSES:

### A DISCUSSION OF THE ENGINEERING PRINCIPLES INVOLVED.*

By C. J. Gadd.

### Burning Powdered Coal.

The process of burning powdered coal is the best method by which to obtain perfect chemical combination of the air and coal, and by which the highest degree of perfection in combustion may be obtained if properly applied. There is no other fuel so responsive to correct application. The greatest precision is required in its control, and it may be said that, so far as the art of burning powdered coal has been developed, it is perhaps in too great a measure dependent upon the human equation.

### Features Necessary for Success.

The essential features necessary for success in the use of this fuel for metallurgical furnaces are:—

(1) That the coal should have a high volatile content—low in ash.

(2) That, after pulverising, the moisture in the fuel should not exceed three-fourths of one per cent.

(3) That, it be pulverised so that at least 95 per cent will pass through a 100-mesh sieve and over 83 per cent through a 200-mesh sieve.

(4) That the delivery of the coal to the furnace be uniformly controlled, regardless of the quantity required.

(5) That it be delivered to the furnace in a thoroughly atomised state, and that combustion be completed while the coal is in suspension.

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* Presented by C. J. Gadd, Chief Engineer, American Iron and Steel Manufacturing Company, Lebanon, Pa., at a meeting of Mining and Metallurgical Section of the Franklin Institute.

(6) That in the application of this fuel the personal equation be eliminated as far as possible.

The use of powdered coal as a fuel necessitates the installation of an efficient crushing, drying, pulverising, conveying, and distributing equipment and, in addition, ample storage room for coarse coal.

### Storing, Drying, Pulverising, &c., Equipment.

Fig. 1 shows a plan, side elevation in part section, and four cross-sections of a coarse coal storage, drying, pulverising, and conveying equipment.

The incoming coal is brought up an inclined plane to the elevated trestle and discharged from cars of the bottom-dump type into the track hopper. A pusher feed located on the bottom of the track hopper controls the flow of coal to the crusher, the crushed coal falling by gravity on to belt conveyor "A," which discharges into the shoe of elevator "B." Belt conveyor "A" is fitted with a Merrick weightometer, which affords an accurate check on the tonnage received. The nature of the coal received determines the operation of the crushing rolls. In the case of slack coal, the crusher rolls are set apart and the coal falls by gravity from the pusher feed through the crusher to the belt conveyor "A."

The discharge from elevator "B" is so arranged that it can either be spouted direct to conveyor "J," which feeds the coal storage bin over the dryer, or to the revolving screen. All coal placed in storage is spouted from elevator "B" to the revolving screen, which sizes it to cubes of 1 in. and under, the finer coal dropping into the hopper below the screen, thence on to flight conveyor "C," which distributes the coal in the storage. The coarser coal is discharged from the screen to the cross-flight conveyor "D," thence on to the flight conveyor "E," from which point it is spouted to cars for use elsewhere.

Under the storage pile two concrete reclaiming tunnels are provided, each equipped with a flight conveyor. Chutes equipped with tunnel gates are spaced at proper intervals on each side of these tunnels, through which the coal from the storage pile travels by gravity on to the flight conveyor "F" or "G," and discharges into the reversible flight conveyor "H," which in turn discharges into elevator "B," from which point it is elevated and spouted to conveyor "J," distributing the fuel in the storage bin over the dryer.

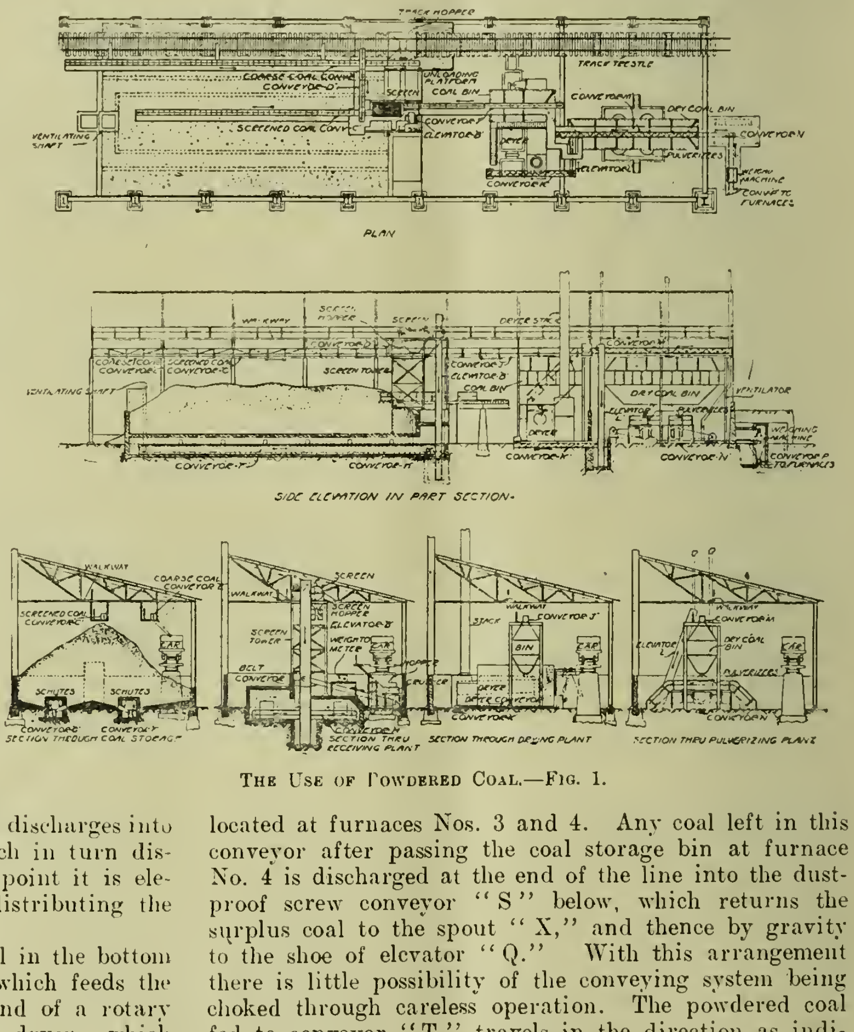
A suitable feeding mechanism is located in the bottom of the coal storage bin over the dryer, which feeds the coal at a uniform rate into the upper end of a rotary dryer. The coal passes through the dryer, which removes the moisture, and is then discharged into the dust-proof screw conveyor "K," thence into the dust-proof elevator "L," thence to the dust-proof conveyor "M," which distributes the dried coal into the dust-proof storage bin over the pulverisers.

From the dust-proof dried-coal storage bin the coal travels by gravity to the feeding mechanism on the pulverising mills. The powdered coal is discharged from the pulverisers into the dust-proof screw conveyor "N," from which point it is conveyed to the weighing machine, which automatically registers the weight of fuel pulverised. A by-pass connecting conveyors "N" and "P" provides a cut-out for the weighing-machine and adjustments, and repairs can be made to this unit without shutting down the system. The weighing machine discharges into the dust-proof screw conveyor "P" connecting with the distributing system.

### The Powdered Coal Distributing System.

Fig. 2 shows a plan and elevation of a powdered-coal distributing system. This equipment furnishes powdered coal to four 50-ton open-hearth furnaces and five double soaking pits.

The dust-proof screw conveyor "P" carries the coal to the dust-proof elevator "Q," which discharges into the dust-proof screw conveyors "R" and "T." The powdered coal in conveyor "R" travels in the direction as indicated by the arrow and feeds the coal storage bins




The Use of Powdered Coal.—Fig. 1.

located at furnaces Nos. 3 and 4. Any coal left in this conveyor after passing the coal storage bin at furnace No. 4 is discharged at the end of the line into the dust-proof screw conveyor "S" below, which returns the surplus coal to the spout "X," and thence by gravity to the shoe of elevator "Q." With this arrangement there is little possibility of the conveying system being choked through careless operation. The powdered coal fed to conveyor "T" travels in the direction as indicated by the arrow and feeds the coal storage bins located at furnaces Nos. 2 and 1. The storage bin at the end of the line into which this conveyor discharges eliminates the possibility of stalling the conveyor. In addition to feeding coal to the storage bins at furnaces Nos. 2 and 1, all the coal used by the soaking pits is conveyed over this line. The dust-proof screw conveyor "U" feeds the powdered coal to the five storage bins located at each of the five double soaking pits. Each storage bin at the

open-hearth furnaces and soaking pits is equipped with an automatic weighing machine, recording the weight of coal fed to each furnace, and the coal from these scales is distributed in the storage bins by the dust-proof screw conveyors "W."

From the time the coal leaves the dryer to its delivery in the furnace the whole system between these points should be dust-proof and the greatest care should be taken to prevent leakage. This should be guarded against systematically, as leaks, however small, may permit the suronnding air in the room to become impregnated with coal dust to such an extent that a serious explosion may result.

Coal, after pulverising, should be handled in bulk. All types of aerial propulsion and transfer in the form of dust clouds should be avoided, for the reason that accidental ignition may at any time wreck the whole system.

Screw conveyors and bucket elevators equipped with dust-proof casings are best adapted to handling powdered coal in bulk. Screw conveyors of 9 in. and 12 in. diameter should not exceed 250 ft. and 300 ft. respectively, if the best results are to be expected. Where transmission lines of greater length are necessary they should be divided.

The storage of powdered coal in large or small quantities for any length of time is not advisable, owing to its tendency to fire, collect moisture, and pack.

Powdered coal in storage, containing about three-quarters of one per cent moisture and one per cent sulphur, will invariably fire within six days. If the moisture be increased to over one per cent and the sulphur to four or five per cent, spontaneous combustion may occur within twenty-four hours. Probably the temperature at which powdered coal is delivered to the storage bin, and the sulphur content of the coal, influence the rate of spontaneous combustion rather than moisture.

Owing to the hygroscopic nature of dried powdered coal, long storage is not desirable.

In its normal state powdered coal is light and fluffy; after 48 hours' standing in storage, however, the physical arrangement of the particles produces a dense packed mass. So dense does the fuel become that one's fingers cannot make an imressionp even one-half inch deep. To meet ideal conditions, powdered coal should be kept in motion.

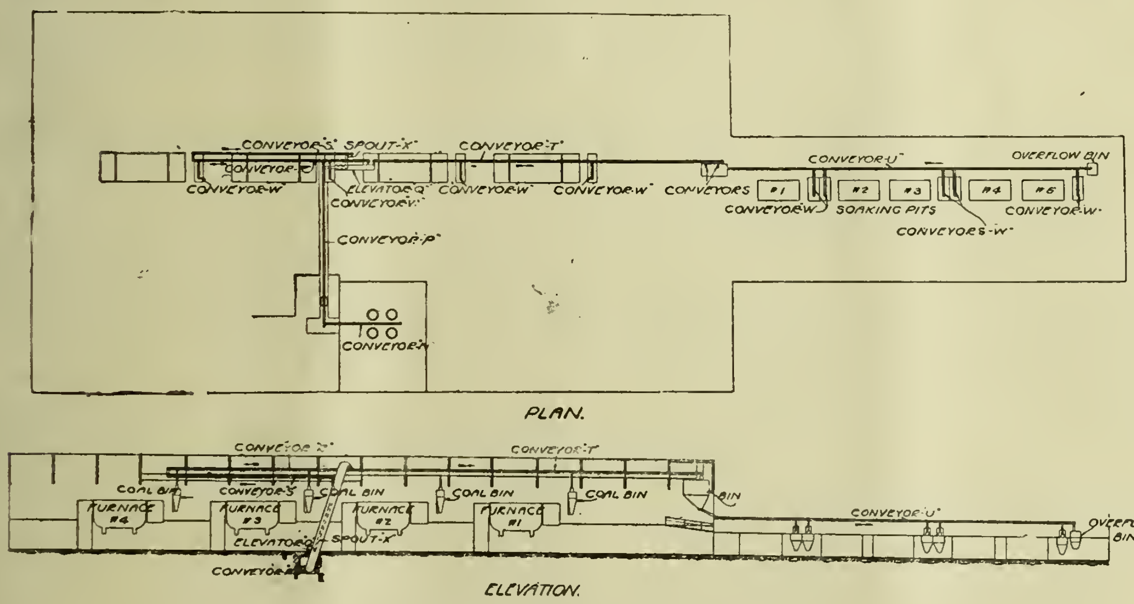
With properly-designed machinery and storage bins, having 12 hours' supply placed at each furnace, the coal may be kept in motion and repairs and adjustments made before the supply becomes exhausted.

**Fuel.**

Low-grade bituminous coals, anthracite, lignites, and even coke breeze in a powdered form, can be burned with good results, certain types of heating furnaces now being operated with such fuels.

It should be understood that the first cost of fuel used is not the correct index by which to judge of economy when fuel must be prepared and pulverised.

Low-grade bituminous coals, being high in non-combustible content, occasion an inordinately high pulverisation cost, as compared to high-grade bituminous coals. Equally, anthracite coals of highest first cost not only add to the pulverisation cost on account of their hardness, but, although having little non-combustible content, their economy in actual use is not to be compared to that of the best bituminous coals, because of their high fixed carbon content, resulting in much slower ignition.




The Use of Powdered Coal.—Fig. 2.

One of the disturbing factors in the use of powdered coal is that of the large accumulations of ash deposited within the furnace, only a small proportion escaping through the stack. When using even a good grade of coal, ash will accumulate rapidly, and therefore fuel of low ash content is always most to be desired.

In obtaining the best economy in any particular case there must be a blending of plant location with the prices of available fuels of varied grades and of the results of tests conducted under operation.

Slack coal is preferable to other forms: it costs less, requires less power for pulverising, owing to its fine state, and materially increases the capacity of the pulveriser.

While the presence of sulphur in small quantities in powdered coal has no ill effect in heating and annealing furnaces, it should be given careful attention when used in the reduction and refining of metals or ores.

Generally speaking, therefore, the fuel available for burning in metallurgical furnaces has a restricted range both as to species and quality. Only the best bituminous coals, high in volatile content and low in both sulphur and ash, are desirable.

Coal used in heating and puddling furnaces should closely approximate the following analysis:—

| | |
|---|---|
| Volatile matter ... ... | Not under 30·00 |
| Fixed carbon ... ... ... | Not under 50·00 |
| Moisture ... ... ... ... ... | Not over 1·25 |
| Ash ... ... ... ... ... ... | Not over 9·50 |
| Sulphur ... ... ... ... ... | Not over 1·00 |

In open-hearth furnaces a still better grade is desirable, a suitable analysis being as follows:—

| | |
|---|---|
| Volatile matter ... ... | Not under 36·00 |
| Fixed carbon ... ... ... | Not under 52·00 |
| Moisture ... ... ... ... ... | Not over 1·25 |
| Ash ... ... ... ... ... ... | Not over 6·00 |
| Sulphur ... ... ... ... ... | Not over 1·00 |

## Drying.

The dryer generally used for the purpose of preparing coal before pulverising is of the revolving cylinder type, provided with an external furnace, usually equipped with an automatic stoking device.

The fuel consumption of the dryer will vary with reference to the amount of moisture to be removed. In drying coal containing about $1\frac{1}{4}$ per cent moisture, to be dried to $\frac{1}{2}$ per cent or less, the fuel consumption should not exceed 26 lbs. per ton.

The power consumption for operating the complete drying unit, which includes the power consumed by the coal-feeding mechanism, the dust fan, the stoking device, and in revolving the dryer cylinder for a 10-ton capacity dryer, figures about $1\frac{1}{2}$ kw.-hours per ton of dried coal.

In the operation of the dryer care should be taken to avoid overheating, in order not to fire the coal or to drive off part of the volatile content.

If the moisture is allowed to exceed three-fourths of one per cent, operating troubles result, and these become intensified the higher the percentage of moisture.

Moist coal reduces the capacity of screen-type pulverisers, as moist coal will clog the screens. Also, the moisture in the coal governs in a large measure the tendency to pack and to arch in the storage bins, causing an intermittent flow of coal to the feeding device and the consequent loss of the one most essential factor, namely, uniform feed to the furnace.

It is easier to dry coal to $\frac{1}{2}$ per cent moisture or less than it is to maintain it in this state. This is explained by the fact that the moisture driven off from the coal in the process of drying saturates the hot air contained in the dryer cylinder. In this highly-saturated condition the air follows the dried coal through the dust-proof conveying system to the enclosed storage bin. As the coal and air cool, moisture is precipitated and the volume of the air diminished, with the result that more warm saturated air is drawn from the dryer. These conditions obviously meet the requirements of a still of fair proportion.

The precipitation of moisture resulting from the cooling process of the coal and air may be almost entirely overcome by placing ventilating shafts on the storage bin and the high points of the conveying system connected with the outside air. Each shaft should be equipped with a ventilator of approved type, and proper provision should be made to collect and deflect any condensation in the ventilating shafts, so as to prevent its return.

It is thus evident that in the process of drying, through the medium of heat, a small quantity of the expelled moisture will find its way back in the coal after cooling. For this reason it is good practice to gauge the dryer so that the resultant product leaving the dryer will contain less than half of one per cent moisture.

## Pulverising.

In order to obtain high efficiency of combustion, powdered coal shoud be reduced to a fineness so that 95 per cent wil pass a sieve of 100 meshes to the linear inch and so that 83 per cent will pass a sieve of 200 meshes to the linear inch. Greater degrees of fineness will undoubtedly produce higher efficiency of combustion.

Machinery for pulverising is adapted to two systems of coal-dust burning. In one system the pulveriser has a capacity sufficient for one furnace and delivers the powdered fuel directly into the burner without intermediate storage. In the other system the pulverisers have a large capacity, and one unit will pulverise enough coal to operate several furnaces, the distributing system being so arranged that the powdered coal is conveyed to storage bins, preferably near the furnaces.

There are a number of designs of pulverising machines of merit on the market, but only one will be briefly described in this paper.

One of the pulverisers largely used is the Fuller-Lehigh mill. The material to be reduced is fed to the feeder hopper of the mill from an overhead bin by gravity. The feeder is mounted on the top of the mill and has a range of three speeds; in addition, the feeder hopper is provided with a slide, which permits the operator to increase or decrease the amount of material entering.

The pulverising mechanism consists of four unattached steel balls, which are propelled around the grinding ring by means of pushers attached to the mill shaft. Above the grinding ring and the balls is a fan having two rows of blades, one above the other. The lower set of fan blades lifts the finished product from the pulverising zone into the chamber above the grinding ring, where it is held in suspension by means of the fan action of the upper row of blades until it is floated out through the screen, which completely encircles the separating chamber. The finished product is discharged through a spout which may be placed at any one of four quarters of the mill. All material discharged from the mill is finished product, and requires no subsequent screening.

These machines are eminently suited for the production of finely-ground material. They have a high mechanical efficiency, and are economical in cost of installation, operation, and maintenance.

In the process of pulverising. a large part of the heat generated is absored by the coal and contained air. The temperature which they attain is high enough to expel part of the moisture in the coal, while the air is of a sufficiently high temperature to establish satisfactory saturation.

The coal and air cool off in their course through the dust-proof distributing system to the enclosed storage bins, and a similar condition exists as in the case of dried coal as heretofore referred to. Similar attention must be given to ventilation; otherwise it would be a common occurrence to find water dripping from the bottom of storage bins ten or twelve hours after filling.

The pulverisers, after being shut down, sweat in cooling, and proper ventilation is the only preventive.

The power consumption of the pulveriser will vary

according to quantity of output and degree of fineness of the finished product. Pulverising mills of the type described, having a capacity of about four and one-half tons per hour, pulverising to a fineness so that 95 per cent will pass through a 100-mesh sieve and 83 per cent through a 200-mesh sieve, will consume about 10·5 kilowatts per hour per ton of product.

In a plant having an average output of 200 tons of powdered coal per day the cost is as follows:—

| | Per gross ton of coal produced. |
|---|---|
| Fuel for dryer | $0·030 |
| Repairs, buildings, machinery, and equipment | ·200 |
| Labour | ·150 |
| Power and light | ·215 |
| Supplies | ·005 |
| | $0·600 |

The above figures include all costs, from the receipt of the coal in the cars to its delivery in a powdered state in the furnace. No allowance has been made for overhead and depreciation.

Shrinkage in the coal becomes a prominent factor, and must not be lost sight of. It may vary from 150 lbs. to 270 lbs. per gross ton.

(*To be continued.*)

## TECHNICAL EXPERTS IN ENGINEERING LAW CASES.

[Contributed.]

### Three Kinds of Liars.

According to some unknown authority, there are three kinds of liars, viz., the "ordinary" liar, the "d——" liar, and the expert witness, a statement which is certainly not very flattering to the last-mentioned individual.

Expert witnesses nowadays play a very important part in the engineering cases which pass through our law courts from time to time.

When a workman sues his firm for compensation for the loss of a limb, sustained whilst working one of the firm's machines, one or more experts may be called in to give evidence for each side.

The experts called in for the claimant will perhaps endeavour to prove to the judge who tries the case that the machine on which the accident occurred is defective in some way, or not efficiently guarded, whilst those called in for the defendants try to show that the opposite is the case, or that there has been carelessness in working the machine.

Now there seems to be a general impression that the fees charged by these expert witnesses are excessive, in fact, out of all proportion to the work they are required to do.

### The Work of Expert Witnesses.

To the ordinary individual, all that an expert appears to do is to inspect the machine, write a report on the same, attend the law courts to give evidence, and then pocket ten or twenty guineas, or perhaps considerably more. To inspect the machine and make a report is commonly believed to be a very simple matter, but this belief is in many cases a most erroneous one. As a matter of fact, to prepare a really satisfactory report will often involve an excessive amount of work, although the report itself may be contained on a couple of sheets of foolscap.

### A Case in Point.

Take, for instance, a case which recently came under our notice, where, owing to the failure of a large hydraulic crane, a man lost his leg. The technical witness called in for the defendants had in this instance to make a special long journey to inspect the machine. It was then found necessary to sketch and measure up the machine, after which a fully-dimensioned and coloured drawing was made for the use of counsel. In order to determine whether or not the machine was strong enough to sustain the load it had been designed for, it was necessary to go into some elaborate calculations, after which the report could be drafted out and finally typed. In addition to this work, the expert, as is generally the case, had to have conferences with counsel and so on. Frequently, it is necessary to modify the report or prepare a further one. Then, again, it has to be remembered that an expert witness must leave his business and attend the courts, where he may have to idle away many hours waiting for his case to come on. Finally, he has to face the trying ordeal of going into the witness-box and being subjected to cross-examination by the opposing counsel, an ordeal which only those who have had to face can "appreciate," and one the anticipation of which may cause sleepless nights to a nervous witness.

All this is typical of the work of an expert witness. Can it then be wondered at that the technical expert, realising the great amount of work which may be involved, and the fact that everything else must be put on one side for the time being, requires a high fee for his services? As a matter of fact, there are few engineers who care to take on work of this nature, and the experienced expert witness can always command a high fee.

In view of these facts, therefore, it will be agreed that an expert usually earns every penny of his fees. As for the expert witness being the worst form of liar, well, we may leave this to the sober judgment of our readers. We may say, however, that a very few experiences in the witness-box will convince anyone that the truth fits in every time, and that he who tries to make false statements will be very badly handled by the opposing counsel.

## FUEL ECONOMY.

(*Continued from page 16.*)

### Usable Coal Left in Mines.

The foregoing figures for the total outputs of our mines by no means represents the real state of depletion of our available coal reserves. A vast amount of usable coal is left behind in the mine because, under present individualistic conditions, it does not pay to bring it to the surface. A larger profit on the capital of a colliery company can often be earned by working the better classes of coal and leaving the less valuable grades underground. According to figures issued in the Report of the 1905 Royal Commission on Coal Supplies, this wasteage amounted to nearly 25 per cent of the total raised in the larger coalfields. The question of checking this wastage by finding out in what ways the less valuable grades can be turned to good account commercially is one of supreme national importance, and the Committee desires to draw special attention to it. Much of the coal now left behind in the mines ought to be converted into

useful forms of energy and products for public purposes, and one of the most important aspects of the fuel-economy problem in Great Britain is the devising and organising of means for making it possible to raise this hitherto wasted coal at an economic advantage.

### Saving in Coal Consumption.

So much for the general statistics of coal production. Coming now to the possible saving in the coal consumed annually in this country at the outbreak of war (nearly 200,000,000 tons), it will be remembered that the 1905 Royal Commission on Coal Supplies found that the possible saving in our then annual coal consumption (167,000,000 tons) amounted to between 40 and 60 million tons. There are many competent judges who consider that, notwithstanding the improved apparatus which has been put into use in the best factories throughout the country during the last ten years, the average result obtained for the country as a whole still lags behind the best obtainable to-day in as great a proportion as it did in 1905. It will be the business of this Committee (1) to estimate as nearly as may be the present possible margin of saving, and (2) to point out the particular directions in which it can be attained from a national point of view.

### The Committee and its Work.

Having regard to the magnitude of its work, and the fact that the coal question is one upon which almost every branch of manufacturing and transport industry is dependent, the original Committee of 13 members appointed by the Association in October, 1915, decided to exercise somewhat freely its powers of co-option, so as to make a General Committee sufficiently large and representative of all the important interests involved.

For the more detailed and special study of particular aspects of the fuel question the enlarged General Committee resolved itself into the following five sub-committees, each of which subsequently elected its own chairman, and subject to its reporting from time to time to the General Committee, proceeded to make such arrangements as seemed best for the prosecution of its work :—

(*a*) Chemical and statistical.

(*b*) Carbonisation.

(*c*) Metallurgical, ceramic, and refractory materials.

(*d*) Power and steam raising.

(*e*) Domestic heating and smoke prevention.

The General Committee next appointed an Executive Committee, composed of the chairman and secretary of the General Committee, the chairman of each sub-committee (ex-officio), and 12 other members, which could meet frequently in London for the discussion of matters relative to the organisation and co-ordination of the work of the Committee as a whole, to deal with matters arising out of the proceedings of the sub-committees which might require immediate action or decision, and to receive and consider communications either from Government Departments or technical associations concerning subjects under investigation by the Committee.

The General Committee has met in London four times since its appointment in October, 1915, the various sub-committees have each met about four times since their formation in January, 1916, whilst the Executive Committee has met regularly on alternate Fridays since April 28th last. In all, 30 meetings have been held during the year.

### Conferences of Manufacturers.

At the first meeting of the General Committee it was decided to organise a series of conferences of manufacturers and others interested in the fuel question in a number of the larger industrial centres, for the purposes of arousing interest in the work of the Committee of inviting co-operation and suggestions from large users of fuel, and of educating public opinion in respect of the national importance of the question. Six conferences have already been held, as indicated in Table III. :—

TABLE III.

| Date. | Place. | Under the auspices of |
|---|---|---|
| 1915. | | |
| November 19.. | Stoke-on-Trent | English Ceramic Society. North Staffs. Mining Institute. |
| 1916. | | |
| March 6........ | London ....... | London Section of the Society of Chemical Industry. |
| March 13...... | Middlesbrough .. | Cleveland Institution of Engineers. |
| March 29 ..... | Nottingham .... | Nottingham Section of the Society of Chemical Industry. |
| April 5 ....... | Manchester ..... | Manchester Section of the Society of Chemical Industry. |
| April 6 ....... | Sheffield ........ | Sheffield Society of Engineers and Metallurgists. |

All but one of the meetings were addressed by the chairman and one or more of the other members of the Committee, and the discussions which invariably followed were productive of valuable suggestions or information regarding local conditions which demand special consideration. It may be also mentioned that the chairman lectured at the Royal Institution of Great Britain, on Thursdays, January 20th, 27th, and February 3rd last, on "The Utilisation of the Energy of Coal."

In March last the Committee was asked by the newly-formed Central Coal and Coke Supplies Committee of the Board of Trade to make suggestions as to economies in fuel consumption which could be made at the present time, and, as the result of further correspondence upon the matter, it was arranged that Sir Richard Redmayne should act as the representative of the Board of Trade Committee on this Committee.

During the first year of its existence the attention of the Committee has been fully occupied with questions of organisation and a preliminary survey of the ground which must be explored later on. Already several important lines of investigation needing the co-operation of manufacturers have been instituted and are well in hand. But the returns are in most cases not yet sufficiently complete to justify publication in the report, and, in view of the importance of the interests and issues involved, the Committee feels that it would be premature to issue any detailed report on particular aspects of the fuel question until its inquiries have reached a more advanced stage than at present.

The Committee recommends that it be re-appointed to continue its investigations, as outlined and foreshadowed in this report, and, in view of the considerable expense involved in carrying out such work, it feels justified in asking for a grant of £100.

(*To be continued.*)

# POWER PLANT EFFICIENCIES.

Notwithstanding the fact that the efficiency of all kinds of power plant has within recent years been greatly improved, it is surprising what a small fraction of the heat energy put into the plant is transformed into useful work, or, in other words, what a large amount of the energy is wasted in one way or another.

## A Modern Steam Plant.

Consider the case of a modern steam plant comprising boilers, economisers, superheaters, turbines, and electric generators.

Of the total heat contained in the fuel burned in the furnaces of the boilers, about 10 per cent is lost by radiation and incomplete combustion, whilst from 25 to 30 per cent is carried away with the gases flowing to the economiser chamber. The economiser will generally utilise about 15 per cent of the heat energy in the fuel for heating the feed water, so that considerably less heat passes away to waste than would otherwise be the case.

If the heat lost from incomplete combustion of the fuel and radiation be 10 per cent, and that carried away with the waste gases flowing to the economiser chamber be, say, 25 per cent, then 65 per cent of the heat is utilised in the boiler and the superheater, and we may therefore say that the combined efficiency of the boiler and superheater is 65 per cent. Since about 15 per cent of the heat is returned from the economiser, we see that the combined efficiency of the boiler, superheater, and economiser is 80 per cent, a figure which is now frequently realised in the most up-to-date steam plants.

We have thus, in the very best plants, as much as 80 per cent of the heat in the fuel given to the steam, and we may next consider how this heat is used up in the turbines, etc.

## Where Heat is Lost.

In the first place, a certain amount of heat will be lost in pipe radiation, auxiliary water heating, and so on, and the extent of this loss may be taken to be about 7 per cent of the heat in the fuel. The energy actually employed in driving the turbines will be about 15 per cent as a maximum, and the remainder of the heat, *i.e.*, 80 – 7 – 15 = 58 per cent is lost in the turbine and the condenser. Thus we have not more than 15 per cent of the heat energy in the fuel available in the form of mechanical work. Of this, a certain percentage will be lost in overcoming the friction of the electric generator and the turbine; if we assume the combined mechanical efficiency to be ·80, the loss in friction will be approximately 3 per cent of the heat in the fuel, leaving 12 per cent available in the form of electrical energy.

Some of this electrical energy will, of course, be lost in the mains, etc., and, assuming an efficiency of ·85, the loss will be 1·8 per cent. This leaves 10·2 or, say, 10 per cent of the energy of the fuel available at the consumer's terminals, *i.e.*, only one-tenth of the total heat energy of the fuel.

## The Case of a Suction Gas Producer Plant.

Now take the case of a suction gas producer plant, consisting of the producer (with boiler), gas engine, and electrical generator. Of the total heat contained in the fuel burned in the furnace, roughly 30 per cent is lost as a result of radiation and incomplete combustion, whilst about 2 per cent of the heat is lost in the auxiliary apparatus. The efficiency of the producer may therefore for the moment be taken to be about 70 per cent. A certain gain, however, results from the use of the steam from the boiler in the producer, and the extent of this gain may be taken to be approximately 12 per cent. The actual efficiency of the producer and the auxiliaries will therefore be 82 per cent. In other words, 82 per cent of the heat energy of the fuel is present in the producer.

Of this energy, a certain amount is carried away by the exhaust gases from the engine, whilst a further quantity is carried away by the jacket water. These two losses may be taken to be respectively 30 and 24 per cent of the heat in the fuel. Of the heat exhausted by the engine, *i.e.*, 30 per cent roughly, 13 per cent goes to the atmosphere and 17 to the boiler, and of the latter 5 is lost in the boiler, the remaining 12 being returned in the form of steam to the producer.

The heat transformed into mechanical work will be approximately 28 per cent of the heat energy of the fuel, and this work is distributed as follows:—The loss in the engine and the generator through friction, assuming the combined mechanical efficiency of the engine and generator to be ·80, will be, say, 5·5 per cent, leaving 22·5 per cent available in the form of electrical horse power. Assuming, further, an efficiency of ·85, the actual loss in the mains, etc., will be 3·5 per cent of the energy in the fuel. This leaves 22·5 – 3·5 = 19 per cent of the fuel energy available at the consumer's terminals.

In this case the plant is seen to have a much higher efficiency at the terminals than the steam plant has; almost twice as much, in fact.

## A Diesel Oil Engine Plant.

Finally, take the case of a Diesel oil engine plant consisting simply of a Diesel engine and an electric generator. In this case, the fuel is burned first in the cylinder of the engine, and of the total heat developed by the combustion, about one-quarter is carried away with the exhaust gases, one-third is transferred to the jacket water, whilst the remainder, or roughly 42 per cent, is transformed into mechanical work for driving the engine piston. Now let us see how this mechanical energy is disposed of. In the first place, we may take it that an amount of energy equal to 10 per cent of the heat energy of the fuel is used up in overcoming the friction of the engine and the air compressor used in conjunction with the engine. This leaves 32 per cent of the energy of the fuel available in the form of actual driving power for driving the electric generator. The latter obviously represents brake horse power expressed as a percentage of the energy contained in the fuel. If we assume the mechanical efficiency of the generator to be 95 per cent, the power available in the form of electrical energy will be

$$32 \times \frac{95}{100} = 30{\cdot}5\,;$$

in other words, approximately 1·5 per cent of the heat energy in the fuel is used up in overcoming friction, etc., in the generator.

We have then, roughly, 30·5 per cent of the heat energy in the fuel available as electrical energy. Assuming an efficiency of ·85, a loss of 4·5 per cent would occur in the mains, etc. Hence, the electrical energy actually available at the consumer's terminals will be roughly 26 per cent of the energy in the fuel.

Comparing now the three cases chosen, viz., the steam plant, the suction producer, and the Diesel engine plant, it is seen that the latter gives by far the best return,

whilst the steam plant gives the worst. Thus, in the case of the steam plant, only 10 per cent of the energy in the fuel is available at the consumer's terminals, but in the Diesel plant as much as 26 per cent is available. As regards the suction producer plant, 19 per cent of the heat energy is available at the consumer's terminals.

## EVOLUTION IN VENTILATION HYGIENICS.

By James Keith, A.M.I.C.E., M.I.M.E., M.I.Mar.E., Etc.

### The Question of Better Ventilation.

Within recent years public opinion has been much exercised on the question of better ventilation of public buildings, offices, etc., and of better conditions for the workers in overheated and ill-ventilated rooms on land and at sea, and for travellers on underground railways, etc.; and the object of this article is to place on record the author's views on some of the most vital issues, as well as some up-to-date methods and practical applications in the science of ventilation.

The subject may be conveniently discussed under the following headings:—

1. Ventilation generally.
2. Mechanical Ventilation in particular (cooling and ventilating overheated engine-rooms and the like).
3. Positive, so-called Natural, and Negative Ventilation.
4. Forced Draught for War Vessels.
5. Subway or Underground Railway Ventilation.
6. Warming and Ventilating by Conduction and Convection.
7. Ventilation of Offices, large Public Buildings, etc.

### 1.—VENTILATION GENERALLY.

The author has long had before him the words of the late Professor Fleeming Jenkin, delivered in a lecture on "Domestic Sanitation" before the members of the Edinburgh Philosophical Institution in January, 1879:

"The ideal condition of comfort and healthiness is that represented by a hillside on a still spring morning, when the sun is shining brightly, and there is frost in the air."

Although it may be practically impossible to attain artificially to this high standard, without doubt this is the ideal to be aimed at.

Good ventilation means not only continuous changing of the air, but also a continual movement in the air without production of unpleasant draughts. This desirable result, when effected, of itself goes a long way towards approaching the conditions of the "still spring morning," and is arrived at in complete disregard of erroneous theories as to the chemical impurity of the atmosphere due to excess of carbonic acid gas.

### Carbonic Acid Need Not be Considered.

The author has long felt justified in believing that in planning for efficient ventilation carbonic acid need not be considered at all, although the public has been led to believe that the carbonic acid test is the only reliable guide. He believes that his practice conforms with the dictum of one of our leading physiologists—Professor Leonard Hill, F.R.S.:—

"The essentials required of any good system of ventilation are:—(1) Movement, coolness, proper degree of relative moisture in the air; (2) reduction of the mass influence of pathogenic bacteria. The chemical purity of the air would be adequately ensured by attendance to the essentials."

When, therefore, what may sometimes be called "bad ventilation" is felt in crowded rooms or confined spaces indifferently supplied with fresh air, the real reason may be, not chemical impurity at all, but possibly some other atmospheric or temperature conditions which may be diminishing the metabolism and affecting the heat loss of the bodies of those present.

The work of physiologists of recent years has gone to show that the whole effect of good ventilation and open-air treatment is due to the movement, temperature and moisture of the air, and has nothing to do with its chemical properties.

To quote again from Dr. Leonard Hill:—

"Physiological experiment has conclusively shown that the percentage of carbonic acid in crowded rooms has nothing whatever to do with the cause of discomfort, for this simple reason: carbonic acid cannot get into the body. The respiration is so controlled by the breathing centre that the excess of carbonic acid (in the atmosphere) cannot enter the body, and the percentage of carbonic acid in the lungs is always kept the same. We can therefore dismiss carbonic acid as having anything to do with the question. The excess of carbonic acid in a crowded room, if anything, will only make people breathe a little more deeply. There is no easier way than to let them breathe an excess of carbonic acid. As to the question of oxygen in the atmosphere, there again the oxygen in a crowded room is never diminished by more than 1 per cent. The diminution of 1 per cent of oxygen has no physiological effect whatever."

This confirmatory statement appears quite sufficient justification for leaving the *chemical* purity of the air to take care of itself, and for considering only the realities or *essentials*.

Again quoting from the same authority:—

"All the efforts of the heating and ventilating engineer should be directed towards cooling the air in crowded places, and cooling the bodies of the people by the setting in motion of the air by means of fans."

This recommendation, of course, contains nothing new in itself. It is still to be realised, however, that, in order to be satisfactory and successful without production of uncomfortable draughts, the plan adopted must be designed and carried out to suit the circumstances, and particular appliances must be used.

### Ventilation at the Royal Society's Rooms.

The author has, in various forms, and after trials on a large scale, for years adopted a system of ventilation of which he believes an example (the apparatus being portable and for summer use only) was independently carried out by Professor C. V. Boys, F.R.S., at the rooms in which the soirées of the Royal Society have been given for many years, and where the guests previously suffered much discomfort from insufficiency of fresh air.

This system, briefly stated, consists in causing air from the outside to be poured in in more or less volume laterally—but without distributing ducts—into the places to be ventilated and without the production of unpleasant draughts, which, of course, cannot be accomplished properly, efficiently or economically without the use of mechanical means.

Although the open fire and wide chimney ensure ventilation, they suffice only for comparatively small rooms when not crowded, and when no tobacco smoking is being indulged in. Great Britain is practically the

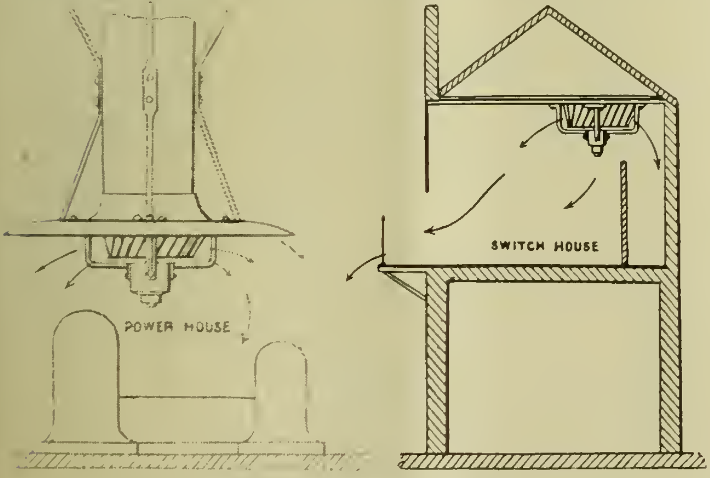
only country in the world where such open fires are in general use.

As this article deal principally with mechanical ventilation and the solution of some new problems in connection therewith, various examples are gives under the different heads following:—

Of late there has been considerable controversy in the Press as to the advisability of allowing tobacco-smoking in theatres, public halls, restaurants, and other crowded places in the same way as it is now permissible in music-halls or variety theatres. The suggestion, when scientifically considered, is one to which there really ought to be no objection, but, if anything, a preference for it, provided always a sufficient and suitable system of mechanical ventilation be installed. Tobacco smoke, being one of the best and simplest of disinfectants, is of itself beneficial rather than injurious in crowded assemblies; only, it is absolutely essential that an independent and most efficient extract system of mechanical ventilation be provided so that the smoke or fumes or effluvia may be immediately carried off from above and not allowed to cool and descend again amongst the people. On the other hand, nothing could be more disagreeable or injurious than to allow tobacco-smoking in excess in crowded and heated rooms when there is no separate and proper mechanical ventilation provided for the instant and continual removal of the products—a state of things unfortunately often found to be the case in the lounges of even the most fashionable hotels. This matter is again shortly dealt with further on under heading 5, *i.e.*, "Subway or Underground Railway Ventilation."

## 2.—MECHANICAL VENTILATION IN PARTICULAR.

In recent times one of the most important branches of the problem to be solved has been that of properly cooling down or ventilating overheated engine-rooms, above ground, underground, or underdeck of electric power stations, workshops, steamers, etc. This branch flooding of these rooms or places with fresh air laterally



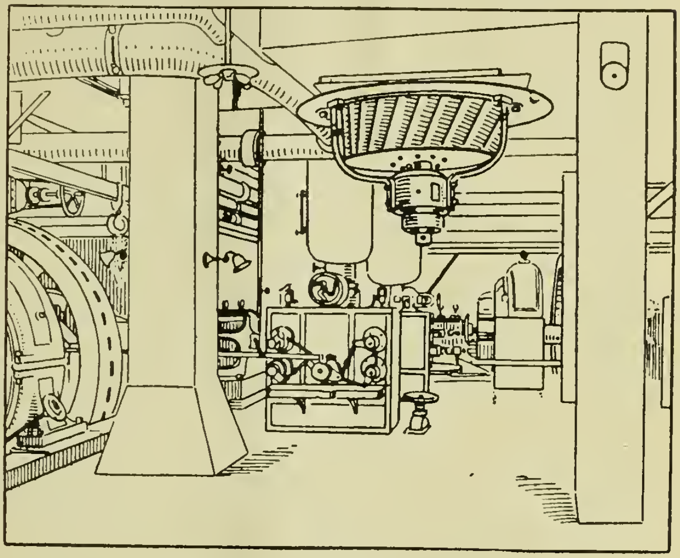

Ventilation Hygienics—Fig. 1.

in volume from the outside under slight pressure by fans, without the use of air-delivery conduits inside.

The following may be cited as successful examples in this respect in recent practice:—

### The Electric Power House of St. Denis.

Fig. 1 illustrates part of the large electric power-house of St. Denis, outside Paris. It shows how the long switch-house (with switchboard about 500 ft. in length) has been satisfactorily cooled down. In this case a series of 10 open fans, each having 25 in. diameter air inlet and running 700 revolutions per minute (direct-electrically driven), are installed along the whole length of the switch-house ceiling, and deliver in all 90,000 cubic



Ventilation Hygienics—Fig. 2.

feet of fresh air per minute, or 5,400,000 cubic feet per hour, and distribute it in the direction shown by the arrows across and through the switch-house into the power-house. In other words, the whole cubical air contents of the switch-house are changed every 40 secs. or 90 times an hour, and the inside temperature of the power-house. In other words, the whole cubical air summer to that of nearly the normal outside atmosphere, without production of unpleasant currents, for a total expenditure in electrical power of 14,000 watts. In the main building or power-house proper there may be, as shown, similar fans of larger size arranged along its length of 600 ft.*

### The Singer Building, New York.

Fig. 2 shows a portion of the underground engine-room of the Singer Building, Broadway, New York, in which are installed three large open fans capable of propelling pure fresh air into the engine-room under moderate water gauge to the extent of 120,000 cubic feet per minute, or more than the whole cubical air contents of the engine-room, thus giving a change of air contents more than 60 times an hour, and ensuring comfort and coolness without draughts, under all outside atmospheric conditions.

The system shown has superseded other systems hitherto in use in the engine-room of the Singer Building, and represent a satisfactory solution of the problem how to keep such engine-rooms comfortably cool and healthy. The change of conditions from an excessively high and unhealthy temperature inside to that of a normal out-

* At the St. Denis power-house the switch-board house as erected was wholly open along one side to the power-house, from which emanated heat generated by the rotors of the large electric transformers to such an extent that the working of the switch-board was practically put out of action in summer-time, even though the large windows high up along both sides and ends, as well as the doors at the ends of the power-house, were fully open all the timo.

side temperature is effected in the case of the Singer engine-room by the expenditure of no more than 22 H.P. when the fans are running at full speed. The air displaced mostly escapes towards the floor level into the boiler-house, thus benefiting the ventilation of the boiler-house and promoting the draught up the chimney.

Fig. 3 shows diagrammatically the increasing delivery and dispersion of the fresh air into any similar underground engine-room or other chamber.

### Ventilating the Engine-room of the s.s. "Lusitania."

Fig. 4 is a transverse sectional view of the engine-room of a Transatlantic liner showing the application of the new method for flooding the engine-room with cool fresh air, under moderate pressure, with an efficiency hitherto unattainable.

The air is delivered into the engine-room by a large electrically-run open fan placed at the junction of the lower ends of the air-shafts, so that the full volume of fresh air, equal in this instance to about 150,000 cubic feet per minute, is propelled into and properly distributed through the engine-room without loss from delivery ducts. When desirable, the air in the engine-room may be changed 120 times per hour without uncomfortable draughts.

It will be seen that wind blowing into the funnel-mouth inlets on the top deck naturally benefits the installation and makes the work easier for the open fan or fans below. An essential characteristic of this application is that the cool, fresh, and heavier air over the ocean is *drawn*, not *forced* down, from the upper deck and delivered laterally by specially-designed open fans (of large peripheral area) placed as low down in the engine-room as permissible, so as to flood the whole engine-room with air, the cooler incoming air of greater specific gravity falling towards the floor, displacing the heated and lighter air contents and expelling them bodily up the main hatch or hatches or other exits without the necessity for extract fans.

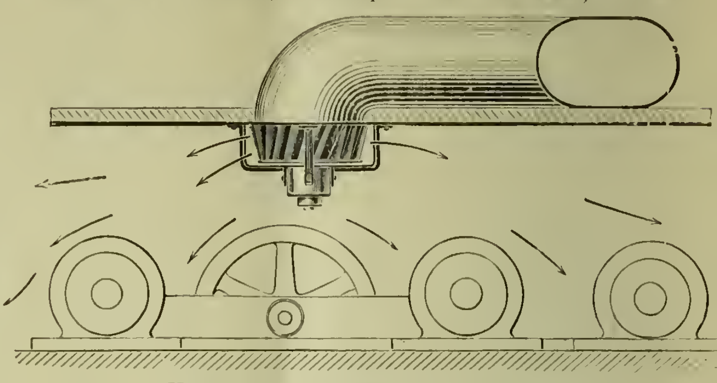
The system shown was installed in the engine-room of the ill-fated s.s. Lusitania in 1912, and was so successful that since then the engine-rooms of the later Cunard vessels, *i.e.*, s.s. Andania, Alaunia, Transylvania, Aquitania, Tuscania, and Aurania, have been similarly equipped.

### Ventilating the Engine-room of the s.s. "Aquitania."

Fig. 5 is a reduced part longitudinal section through the central engine-room of the s.s. Aquitania, showing the arrangement of inlet conduits and fans, and indicating how the change and movement of air are effected at the level of the starting platform some 100 ft. below the upper deck from which the fresh air is drawn.

The main supply of fresh air for the central engine-room is drawn down four vertical shafts, two of which (marked "A") serve one open fan (marked "B"), the other two (marked "C") each serving a separate open fan (marked "D"). These three open fans collectively distribute and diffuse 180,000 cubic feet of fresh, cool, air per minute, without unpleasant draughts, into the lower part of the eigine-room with an expenditure of 66 H.P. In the two wing turbine rooms 120,000 cubic feet of air per minute are distributed by other fans requiring 68 H.P. The condenser and turbo-dynamo compartments receive 120,000 cubic feet of air per minute, absorbing 66 H.P. *For circulating air* in and emitting it (by separate fans) from the various compartments mentioned, 167 H.P. is required, 273,000 cubic feet of air per minute being dealt with in this manner.

In all, in the three engine-rooms proper, with condenser and turbo-dynamo portions included, some

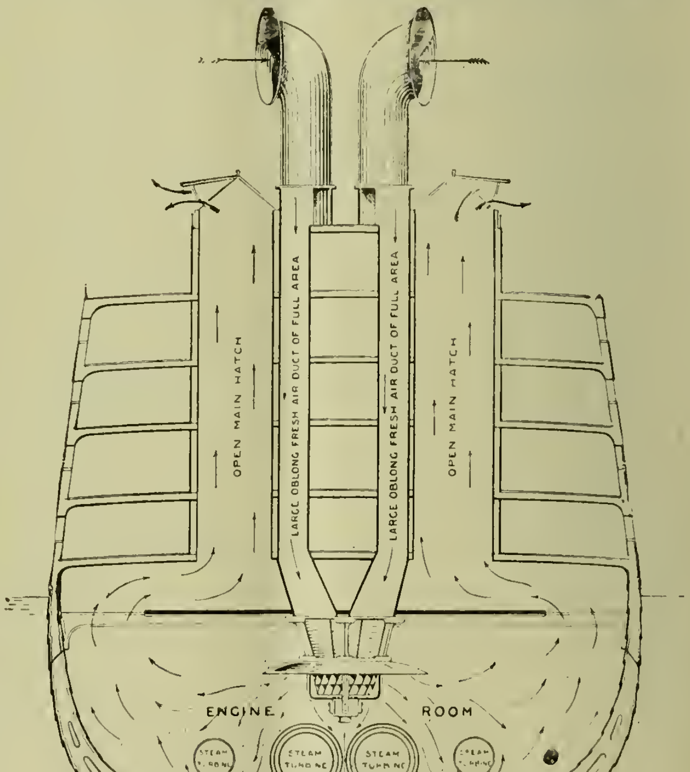


Ventilation Hygienics—Fig. 3.

25,200,000 cubic feet of air are changed every hour, while the air in *circulation* and *emission* is dealt with to the extent of 16,380,000 cubic feet per hour.

The net result is that the atmosphere at these depths is kept fresh and wholesome at an average temperature of about 75 deg. Fah.

A similar result could be obtained by blowing or forcing air downwards by cased fans from the top deck. With similar structural conditions, however, a much higher




Ventilation Hygienics—Fig. 4.

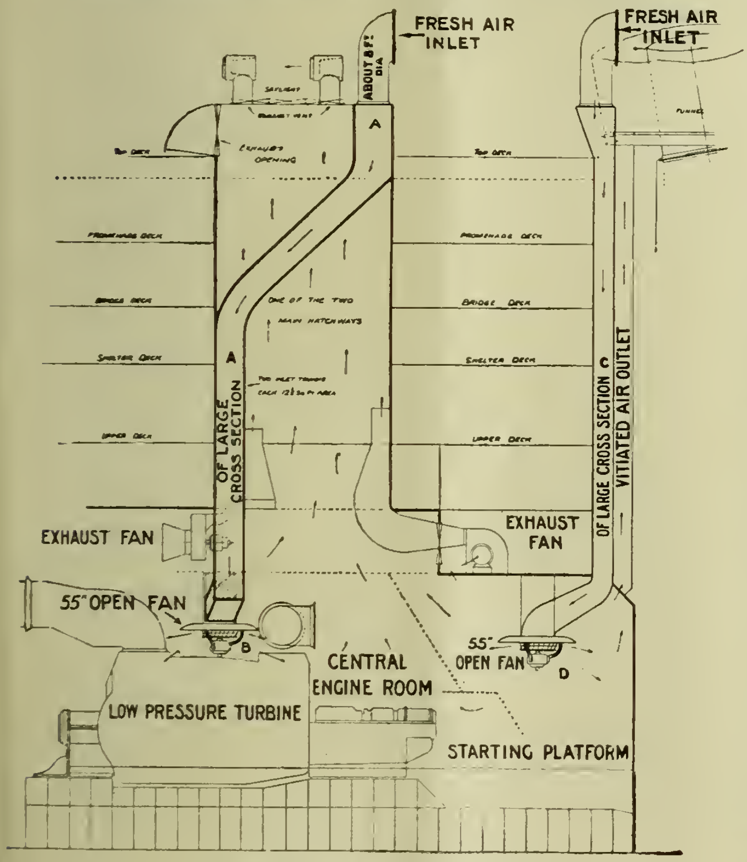
water-gauge pressure would have to be used in order to obtain the necessary velocity and volume below, and the expenditure of horse-power would be considerably greater.

### Reasons for the System.

In this connection, it may be desirable, from the point of view of the power consumption requisite for good ventilation, to point out some of the reasons for the advantages obtained by drawing in the air and distributing it without inside conduits as distinguished from pressing it towards a room.

A fan fitted to the lower end of an air duct may be so arranged that it serves not only to handle the air, but also to diffuse it in a favourable manner over the room to be ventilated. If the air be forced to the room, however, distribution pipes and nozzles are necessary to effect an even ventilation all over the room.

While, therefore in the former case there is only at one place—namely, in the fan—a transformation of energy and change of velocity of the air, in the latter case a second transformation takes place where the air passes




Ventilation Hygienics—Fig 5.

through the nozzles into the room. In the first case the absolute velocity of the air, where it leaves the fan, is used to distribute the air in a favourable manner; in the second case such velocity is lost to a large extent in eddies.

It may also be pointed out that on board ship, when the principle of sucking the air to the room is adopted, it is usually easier to have the smallest number of bends and therefore a more efficient passage for the air till it enters the room. Again, the fan and motor are not so much exposed to atmospheric conditions, and are more easily watched and controlled when fitted in the engine and boiler-room than when arranged on deck.

The only way to obtain the advantage of the additional power necessarily spent in forcing the air downwards, and also to prevent draught currents from nozzles below, would be to use large distributing diffusers in the engine-rooms in order to keep up and deliver there the full volume desired at a lower velocity. In actual practice these points are well exemplified in the case of the s.s. Aquitania, in which, because of machinery difficulties, the two wing engine-rooms are served by the plenum method from the upper deck at a cost of one-third more power than is required for the ventilation of the central engine-room, in which the system illustrated and recommended is installed, the proportions of downward air-ducts and air volumes delivered being identical.

When it is considered that many modern under-deck, as well as underground, engine-rooms have an overheated *windless atmosphere* of from at least 100 deg. Fahr. in winter to 150 deg. Fahr. in summer, the necessity for a practical remedy will be appreciated. Until about four years ago it was not possible to obtain open fans capable of creating a water-gauge pressure of any consequence in a duct or air-inlet and of delivering an adequate air volume into an open space at a fairly high velocity.

*(To be continued.)*

## THE PEROLIN BOILER METAL TREATMENT.

The removal of scale from boilers and the preservation of the metal against pitting and corrosion has always exercised the minds of engineers. The scale deposit decreases the efficiency of the boilers, increases the consumption of fuel, and thereby adds to the cost of steam production. To show how greatly a sure and safe remedy against these troubles is needed, it is only necessary to note the many expedients which have been adopted from time to time without achieving complete success. It was recognised that prevention is better than cure, and that it would be the most rational method to treat the water before and not after it was put in the boiler. This was attempted by installing water-softening plant. The cost of erecting water-softening plants and the expenditure for chemicals, which have to be varied owing to the changes which take place in the composition of the water, are considerable, and as the acids and salts are not entirely removed by any water-softening treatment, the troubles referred to are not fully eliminated.

A solution of the matter has been arrived at by considering the question as an engineering instead of a chemical one, resulting in the introduction of the Perolin boiler metal treatment. Its action is entirely mechanical, for when injected into the boiler its affinity for hot metal is so great that it is at once attracted to the plates and tubes in the boiler through cracks in the scale or at the ends of the scale formation, and by its remarkable expansive property it detaches the scale. When the metal is quite clean Perolin forms a protective film on the metal, and this, being a good heat conductor, adds to the steam capacity of the boiler. This coating prevents any further formation of scale, and where pitting or corrosion is in evidence, will check any further extension of the injury to the metal.

Where there is any oil in the water, Perolin collects it in the form of an emulsion, which is blown out with the mud and slush accumulations from scale-forming ingredients in the water which have been held in suspension by a peculiar "colloidal" action of Perolin. Perolin is an essential ally and aid to a water-softening

plant, as it completes the work by preventing the acids, etc., that find their way into the boiler from a water-softening plant having any injurious effect on the boiler metal. Perolin being non-volatile, is not carried over in the steam and can therefore be safely used in all plants where live steam is required for the preparation of food products.

Perolin has only lately been introduced into this country, but it has already been tested and proved by some of the largest engineering firms in England. It was first tried in the United States about 10 years ago, and later a separate company was formed to deal with the Canadian business. Over 35,000 boilers are at the present time being treated with Perolin, and it is being extensively used by some of the largest railroads in both the countries mentioned, where increased mileage and tonnage and largely decreased cost of fuel and repairs have resulted. Trials of from 30 to 60 days are allowed, provided information is furnished of the state and conditions under which the boilers are worked.

## SHORT CIRCUITS.

By F. Ashton.

In the early days of the electrical industry, when generating plants were nothing like so reliable as they are at the present time, short circuits often occurred in engine-rooms as well as on the mains, and lengthy interruptions in electricity supplies were fairly frequent occurrences. Long experience has led to marked improvements in the details of electrical plants, whilst ingenious devices have been invented for isolating faulty machines and conductors. Meantime, however, electrical systems have been rapidly increasing in size, with the result that short circuits are now apt to be much more destructive than they were in the past. Short circuits on small or medium-sized power stations can readily be dealt with by fuses or circuit breakers, but when it comes to inter-connected stations, with an aggregate capacity of perhaps half a million horse power, the problem of dealing with the enormous rushes of current which are apt to flow as the result of "shorts" is not on the whole an easy one.

### The Inter-connection of Power Stations.

In this country linking up electrical systems has not yet been practised on an extensive scale, although within the last few years there has been substantial progress, and there is little doubt that sooner or later all the large power stations in London will be inter-connected. At present the most important examples of linked-up systems are in America, where many large plants are worked in parallel. The aggregate capacities of these systems range from one hundred thousand to half a million horse power, and when it is remembered that at the instant a short circuit occurs, the rush of current may, under favourable conditions, be as much as forty times greater than the normal current, the importance of adequate protection will be readily appreciated. The closer the inherent voltage regulation of generators, the more heavy is the short-circuit current, especially when the short circuit occurs on the bus bars or just outside the station. But, of course, the short-circuit current which flows when an alternator is running at full speed and fully excited is much in excess of that which would be produced by first connecting the terminals together and afterwards putting the machine into operation. Under the latter conditions the current would not rise to more than 2½ to 3 times its full load value, for the simple reason that the current will under these conditions lag very considerably behind the electromotive force, and it is well known that these lagging currents exert a powerful demagnetising effect upon the poles. If a fully-excited alternator be short circuited, however, while it is running at full speed, the current may attain a value ranging from 20 to 40 times the full load value, for there is no time in the first one-hundredth part of a second for the field to be demagnetised. Consequently, the first rush of current is propelled by the full electromotive force.

### The Rate at which Current Rises.

The rate at which the current rises is determined by the self-induction of the armature windings, and to a certain extent by the distributed capacity between the windings and the frame. Recognising that internal reactance has a marked effect on the short-circuit current, central station engineers are not so keen on purchasing alternators with very close voltage regulation as they were in the past. Experiences with early turbo-alternators taught electrical designers and central engineers some important lessons. It was found, for instance, that when short circuits occurred the heavy currents exerted enormous forces, which in some cases pulled the armature conductors out of their slots. This led electrical designers to look into what could be done in the way of limiting short-circuit currents and to devise new means of bracing the projecting ends of the armature windings so that they remain rigid under short-circuit conditions. In the early days of slow-speed generators, it was known that the sudden rushes of current which occurred at times of short circuits would injure the windings unless they were very strong and well supported. But it was not until after many serious accidents occurred that the designer realised how many times greater were the forces he had to deal with in the case of turbo-generators. The extraordinary forces which are brought into play when these machines are short-circuited are attributable to various causes. In the first place these high-speed machines have comparatively few poles, and the ampere turns per pole are therefore much greater than those on the poles of a slow-speed generator. Further, the span of the coils in a high-speed generator is considerably in excess of that in a slow-speed machine, and the magnetic flux leakage across the slots and around the end windings bears a much smaller ratio to the total flux per pole in the case of many turbo-alternators than it does in the case of the older engine-driven generators. These considerations, however, are more important to electrical designers than to operating engineers. What power-station men are mainly interested in is how heavy short-circuit currents can be effectively dealt with.

### Dealing with Heavy Short-circuit Currents.

Of course the circuit-breaking apparatus at present employed in generating stations in this country are, as a rule, quite capable of taking care of severe short circuits, but it is to be remembered that, as the size of generating sets is increased, and when large power stations are inter-connected, as they are in America, it may be necessary to adopt other precautions. Feeder circuit breakers have been constructed which can safely close and open circuits of over 10,000 horse power capacity, whilst generator circuit breakers have been made for over 40,000 horse power. But however perfect high-capacity circuit breakers and other protective

devices may be, there is always a possibility of something unforeseen happening which will cause all the available energy of a large station or a number of smaller stations to be dissipated at one particular point. Even if all the circuit breakers operate properly the momentary rush of current on an extensive system may, in the absence of special precautions, be enormous. Ever since large electrical plants have existed, the possibility of bad short circuits doing considerable damage to the machines and control apparatus has been a source of worry to operating engineers. To minimise the risk, large plants have, at times of heavy loads, been divided into two or more sections, so that if a short circuit occurred only half or one-third of the plant would be affected. But this arrangement is inconvenient and uneconomical, since two or three independent sections have to be separately regulated, and owing to the impossibility of transferring the load from machines in one section to those in another, it is not easy to operate the station under the most economical conditions. In large stations, where bad short circuits have occurred and serious damage has been averted only by sheer luck, the plant has on more than one occasion been divided into sections. But after a long spell of normal running the engineers have, as a result of the inconvenience involved in running machines on independent bus bars, returned to the older and more convenient method of running all the alternators in parallel.

(*To be continued*).

## LIQUID MANOMETERS FOR LIGHT PRESSURES.

By R. S. Bayard.

An elementary analysis of the principle involved in the liquid manometer, or U-tube, for measuring low pressures of gases, such as chimney and furnace draft, and the effect of unequal tube diameters may be of interest, particularly the question as to whether it makes any difference in the accuracy or the method of reading the instrument if the two glass tubes forming the U are of the same diameter, or "bore." In experimental work it often happens that two commercial glass tubes are not of the same internal diameter, especially if bought at different times, as when replacing one tube after breakage. The effect of this difference is that the movement of liquid will be greater on one side than on the other, and this causes uncertainty in the mind of the observer, and it is surprising how often this question is raised.

If the two tubes are of the same diameter, the downward movement on one side must be exactly equalled by the upward movement on the other side. In Fig. 1 this is shown by a $1\frac{1}{2}$ in. displacement downward at A and a $1\frac{1}{2}$ in. increase of depth at B, making a total "reading" of 3 in. of water, this being equal to the pressure measured.

The area of a $\frac{1}{2}$-in. bore is 0·196 square inch, and so the volume of the water supported by the gas is $3 \times 0{\cdot}196 = 0{\cdot}588$ cubic inch. The weight of a cubic foot of water being taken at 62·3 lbs., the weight of a cubic inch will be 0·03606 lb., and the weight of the column supported will be $0{\cdot}588 \times 0{\cdot}03606 = 0{\cdot}02120$ lb. This weight being supported on an area of 0·196 square inch, the pressure per square inch will be $P = 0{\cdot}0212 \div 0{\cdot}196 = 0{\cdot}10818$ lbs. per square inch.

In this calculation the area of the tube enters into the problem twice—once as a multiplier to get the water volume, and once as a divisor to get the pressure per unit of area, or per square inch. Thus the area of the tube cancels out in the calculation of the pressure, and the net result is simply that the pressure per square inch is the product of the height of water column supported in inches, by weight of one cubic inch of water, or $P = 3 \times 0{\cdot}03606 = 0{\cdot}10818$ lb. per square inch, the same as already found.

The area, or bore, of the tubes therefore has no effect upon the calculation of pressure when both tubes are of the same diameter, but what is the effect when the tube areas are unequal?

Referring to Fig. 2, tube A is $\frac{1}{2}$ in., and the open tube B is but $\frac{3}{8}$ in. bore. As before, let the total column of water supported by the gas pressure be 3 in. The relative downward and upward movements may be obtained by calculation, basing the problem, as before, on the fact that the volume forced out of A must be added to B. If, then, tube A is $\frac{1}{2}$ in. bore and its area 0·196 square inch, and tube B is $\frac{3}{8}$ in. bore and its area 0·11 square inch, then, if $x$ is the depression in tube A, the volume displaced downward is $0{\cdot}196\,x$ cubic inch. Also, as we have assumed the total column to be 3 in. long, as in the first problem, the sum of the depression in A and rise in B must be 3 in., so rise in B must be $3 - x$, and volume added to B must be $0{\cdot}11\,(3 - x)$ cubic inch. But the volume lost by A must equal the volume gained by B, so $0{\cdot}196\,x = 0{\cdot}11\,(3 - x)$, or $0{\cdot}196\,x = 0{\cdot}33 - 0{\cdot}11\,x$; so $0{\cdot}306\,x = 0{\cdot}33$ and $x = 1{\cdot}078$ in., which is

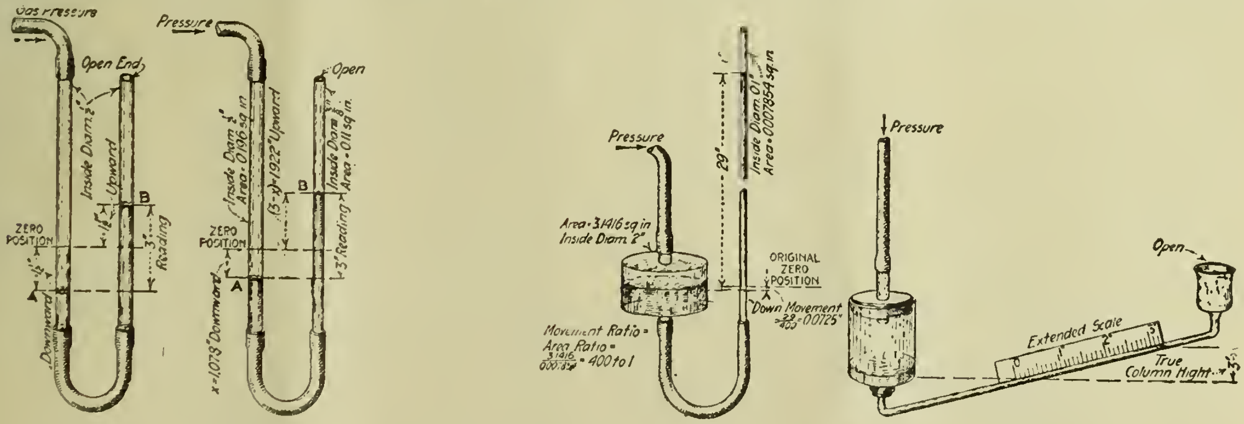



Fig. 1. Fig. 2. Fig. 3. Fig. 4.

Liquid Manometers.

the depression in A. The rise in B must be, as stated, $3 - x = 3 - 1.078 = 1.92$ in.

Thus the water-level movements are unequal, the depression in A being 1·078 in., and the rise in B 1·922 in., the latter being almost double the former.

Now, the pressure represented by the gauge may again be calculated by first figuring the weight of the column of water. The area of tube B, which is now holding the water column, is 0·11 square inch and the upstanding water column is, as before, 3 in.; so the volume is $0.11 \times 3 = 0.33$ cubic inch, and the weight of this column is $0.33 \times 0.03606 = 0.0118998$ lb., and the weight per unit of area, or pressure per square inch, is $0.0118998 \div 0.11 = 0.10818$ lb. per square inch, as in the previous problem.

It makes no difference, therefore, in the result whether the two tubes are of large or small bore, nor does it affect the result if the bore of one tube is greater or less than the other. The only controlling factor is the height of the column, and the pressure measured is always the product of the height of the column by the weight of unit volume of the liquid used. If the height is in inches, the unit weight must be in pounds per cubic inch, and the answer will be in pounds per square inch. If the height is in feet, the unit weight should be in pounds per cubic foot, and the answer in this case will be in pounds per square foot.

The application of the foregoing leads to a practical simplification of the manometer gauge. It was observed that the liquid movement in the larger side of the U was less than that in the smaller one, but that the total height of liquid supported will always be the same for the same pressure and liquid used. It is quite practical to increase the diameter of the pressure side of the U to such an extent that the most of the liquid travel will be in the smaller leg—in fact, so that the movement of the liquid level in the large leg will be negligible. This makes it convenient to arrange the "zero point" at the liquid level of the large-diameter leg and have the entire movement of the column, to all practical purposes, confined to the smaller-diameter leg, and instead of measuring from two moving liquid levels, it is necessary only to measure from the fixed zero point to the height of column in the smaller leg. Of course, there is a small error due to movement of level from zero in the large-diameter leg, but this may be made so little that it is negligible, so that the instrument needs to be observed only at one place—the height of the liquid column in the small tube. Many commercial forms of draft gauges and some cheap barometers work on this principle. Fig. 3 shows such an instrument, the total reading being 29 in., while the corresponding depression of the "zero" side is only 0·0725 in.

In some cases the draft gauge is made on a slant so that the scale may be much extended for close reading. Here the true column of liquid is, of course, the vertical height as before, but the scale may be laid out on the diagonal, or slant, so as to obtain much larger scale divisions for a given vertical movement.

This is shown in Fig. 4, it being understood that the vertical dimension of 3 in. is the true liquid column height representing the pressure, just as in the previous case, but that the diagonal scale is laid off in large divisions so that the scale will read 3 in., even though the diagonal distance may be three times as great in reality. This makes it possible to read very small movements of the liquid column with accuracy. To be accurate, the slant of the tube must be exactly that for which it was calibrated and the instrument set level, as the movement will vary with the slant. Disregarding either introduces a grave error, and the instrument should be carefully levelled when set and ocasionally checked up with a level for accurate work or its reading will be of little value.—*Power.*

## AMERICAN PETROL CATERPILLARS FOR DRAINAGE PURPOSES.

The latest development in ploughs for excavating drainage channels of sizes too small to be economically handled by a dredge is the petrol traction engine, mounted on caterpillars. Many years ago a drainage channel plough was invented. Horses were attached four abreast, and frequently 50 miles of channel 8 ft. wide on top, 3 ft. deep, and 18 in. at bottom width, were let on contract prices at from 5s. 2d. to 8s. 4d. per rod. The petrol machine which is replacing these outfits consists of an engine supported on two long caterpillars 30 in. wide, which carry a 16 in. diameter cable drum 24 in. long. This drum is driven from the main shaft of the 60 H.P. engine, and is geared to give a rope speed of 14 ft. to 18 ft. per minute, depending on the amount of cable on the drum. About 1,000 ft. of $1\frac{3}{8}$ in. wire rope is used. When, on account of difficult ground or for other reasons, the tractor must be set at greater distance from the plough, removable lengths of 500 ft. or 600 ft. of wire rope are attached between the plough and the end of the cable. In operation, the plough, removed from its four-wheel carriage, is left at the starting-point of the channel, the cable attached to its beam. The tractor moves ahead to the proper point on the line of the channel, paying out the cable as it advances. The traction gear is then released and the drum thrown in. As soon as a strain is taken on the cable, two anchor flukes drop to the ground and bite in as the tractor moves backward until the latter is securely anchored. When the plough is drawn to the end of the cut, the drum is thrown out of gear and the tractor thrown in. As the tractor advances, the anchors ride up from the ground, and are hooked up in the clear bypower. One man and a helper are required to operate the tractor, while another man rides the plough. A team and driver are employed in hauling supplies, and a cabin on wheels, presided over by a cook, furnishes food for the crew. The plough, weighing four tons with its removable truck, a wagon loaded with cables and supplies, and the cook wagon are hauled by the tractor over ordinary country roads at the rate of two miles per hour. Although the tractor weighs 15 tons, its large bearing surface enables it to travel over swamp land too soft to support a team. A plough of increased size, which will cut drains 2 ft. in bottom by 9 ft. in width, and 3 ft. 6 in. deep, is used with the tractor. The caterpillars are similar to those that have been applied to the so-called "Tanks" for war purposes.

Swedish Electric Furnaces.—Considerably over 100,000 tons of iron are produced annually in the Swedish electric reduction furnaces. The process has now been developed in Sweden so that the molten pig is delivered direct to the open-hearth furnaces, heated by the gases from the reduction furnace, and, finally, the charge from the open-hearth furnace is poured into an electric refining furnace, and the final steel is of remarkably high quality.

Belt Driving.—Tests made upon the efficiency of belt driving over wooden split pulleys and over cast-iron pulleys, made by Professor H. W. Price at the University of Toronto, showed that efficiencies of 95 to 98 per cent were consistently attained, the advantage being with the wooden pulleys, and that with this type of pulley an efficiency of 98 per cent was readily maintained at belt speeds of 4,500 ft. per minute.

# Trade Items, Notes, &c.

We are informed that, to facilitate prompt delivery and attention, all communications for Messrs. Joseph Sankey and Sons Limited, makers of Sankey steel wheels, etc., should in future be addressed to them at Hadley Castle Works, Wellington, Shropshire.

The statistics issued by the American Iron and Steel Institute give the total production of pig iron in Canada during the first half of 1916 as 507,750 tons (of 2,240 lbs), as compared with 458,595 tons in the second half of 1915 and 366,825 tons in the six months ended June 30th, 1915.

Shale.—A sample of shale from Natal has recently been shipped to England for testing. Experts are of opinion that this shale will yield on an average over 20 gallons of oil per ton. In the Wakkerstroom district the shales are said to be of good working thickness.

Tests of Milling Cutters.—Tests recently carried out in America on milling cutters seem to demonstrate that the wear of the cutter with the wide-spaced teeth is just about one-half of that of the old style stock cutter, and that it is much more uniform. The tests also showed that the best life of the cutter is obtained when the linear feed per tooth is at least 0·002 in.

Dearth of labour is delaying the Standard Shipbuilding Company's scheme at Chepstow. Just under 200 men are employed, but a number have left because they could not obtain house room. If 1,000 men could be obtained the company could employ them. On the site of the dockyard light railway lines have been laid down, and navvies are excavating for the foundations of the engineering shops. Preparations are also being made for the construction of three ships, and slipways are being laid down.

Although it is possible to melt non-ferrous scrap of small size without much waste, it is preferable to form the stuff into briquettes, where fair quantities can be handled, because not only does this prevent melting losses, but it also enables one to charge the crucibles fully without having to feed them with fresh supplies of metal. Cast-iron turnings and borings when formed into briquettes of approximately 7 lbs. each melt very well in the cupola provided they are not rusted. Usually some kind of agglutinant has to be used, while considerable pressure is necessary, special briquetting machines being used for this work.

The Waste of Wood.—There are more than 48,000 sawmills in the United States, says *Power*, New York, and their by-products in the form of sawdust, shavings, slabs, and other wood refuse is estimated at 36,000,000 cords a year, one-half of which, perhaps, serves a useful purpose as fuel under the boilers. Much of the remaining 18,000,000 cords not only is not utilised, but generally is a source of danger and costs the mill time and money to dispose of in various ways. The production of waste is unavoidable, and the Forest Service is seeking out some way of turning it to account

A New German Submarine.—According to a Dutch technical journal there is building in Germany a submarine cruiser of 5,000 tons and 400 ft. in length, "as strongly protected and armed as medium-sized protected cruisers." The propelling machinery is said to develop 18,000 H.P., to give a speed on the surface of 26 knots, and when submerged of 16 knots. The radius action is from 18,000 to 20,000 nautical miles. It is said that the vessel will have 30 torpedo tubes, and that in addition to a torpedo in each tube there will be carried two reserves for each tube, making 90 in all. Provision is also being made for carrying over 100 mines, and for dropping them through the bottom of the ship.

Uniting Dissimilar Metals.—A process for uniting bodies of dissimilar metals is covered by an American patent. The union between the metals is effected by welding, and is relied upon to resist the action of mechanical stresses produced in working the metal as well as changes in temperature. In producing bi-metallic shapes one of the metals has its surface thoroughly cleaned. A thin layer of a metal having a low melting point is then welded to the cleaned surface, and any excess metal is removed. The surface of the other metal, which has been thoroughly cleaned, is then brought into intimate contact with this coating, and the whole heated to a temperature at which an alloy is formed between the metal having the low melting point and the one which it is desired to unite to it.

Launch of the Largest French Liner.—A new Transatlantic liner named the "Paris" was successfully launched at Saint Nazaire on September 12th last. This vessel, which belongs to the Compagnie Generale Transatlantique, is intended for the service between French ports and New York, and will, when completed, be the largest vessel in the French mercantile marine. Her length is 233 metres (764 ft. 3 in.); beam, 29·60 metres (96 ft.); depth of hold, 18 metres (69 ft.); gross tonnage, 37,000 tons; and draught, 9½ metres (31 ft.). The engines will have 45,000 nominal horse power. There will be accommodation for 3,000 passengers.

United States of America Government Nitrogen Plants.—According to the *Electrical Review and Western Electrician*, Congress has passed a Bill authorising the development of hydro-electrical power for the electrical fixation of nitrogen, which will be used in the manufacture of munitions of war, and thus make the Government independent of imported nitrates for this purpose. The President is authorised to cause an investigation of the best means for producing nitrates, etc., by water or other power, to obtain exclusive use of any necessary site for the purpose of the Act, and to provide the necessary equipment, etc. Any surplus product may be sold and disposed of, and may be used in the manufacture of fertilisers. The sum of 20 million dollars is appropriated for the scheme, which will be operated solely by the Government, and not in conjunction with any other industries or enterprises carried on by private capital.

Wireless Telegraphy Patents in U.S.A.—The important valve patents have been occupying the Courts of the United States for a considerable time in an action brought by the Marconi Company against Dr. Lee de Forest for infringement of their Fleming patents, and a counter-action by Dr. De Forest claiming damages for infringement by the Marconi Company. We are informed that judgment was given on the 21st ult. in favour of the Marconi Company. Dr. Fleming's patents were declared to be the master patents, and were not anticipated by De Forest or anybody else. The De Forest audion was held to be an infringement of the Marconi Company's Fleming patents. The Atlantic Communication Co. of America, a subsidiary company of the Telefunken Company, of Berlin, has (it is stated) infringed a number of patents in order to obtain a possible wireless service across the Atlantic, and fearing the action by the Marconi Company against them, which is pending, recently purchased the De Forest patents for 150,000 dollars. Dr. Fleming's "valve," and many infringements of it, have been largely responsible for the developments in the reception of wireless telegraphic messages over long distances. It was the introduction of these "valves" which gave a value to the Poulsen system, and has been principally responsible for such success as the Germans have obtained both abroad and at home in wireless telegraphy. The experiments recently carried out in wireless telephony in the United States, which gave sensational results, were achieved solely by the use of the Marconi Company's Fleming valve patents.

Australian Industries.—Strong efforts are now being made to move official as well as public feeling to a proper recognition of Australia's natural resources. The report on which the Australian Postmaster-General has decided to establish works for the manufacture of wire cable and metal rope states that an expenditure of £250,000 will be needed to secure a turnover of approximately £1,000,000. Positions will be found for 1,000 workmen. Not more than 10 men will be needed from overseas, and all the raw products necessary can be obtained in Australia. An Australian inventor (Mr. John Flint), of Sydney, claims to have succeeded in the world's search of synthetic rubber, and to have found a way of producing an efficient substitute for rubber at a very low cost. The substitute is an entirely Australian product, all the ingredients being obtainable in the Commonwealth, and successful experiments in the vulcanising process have already been carried out with it. The invention has been patented. The claim is made that it can be produced at a price of from 5d. to 6d. per pound, as against the present price of rubber which runs from 3s. to 4s. 2d. per pound. Special attention is being paid to the science of dyes in Australia. At a meeting of the Royal Society in Melbourne, Mr. E. J. Hartung showed a series of synthetic dyes, and pointed out the relationship between chemical constitution, fluorescence, and colour exhibited by certain of the dyes. Mr. Hartung also showed a new dye discovered in the chemical laboratory of Melbourne University, but not yet fully investigated. Mr. Z. Kamiya, Special Commissioner of the Japanese Government to the South Seas and Australia, recently stated in Sydney that Japan would be one of the best buyers of zinc, and to a possibly lesser degree would be a buyer of copper and lead.

# New Companies Registered.

AIRCRAFT ENGINE CO. LTD. (145,027).—Private company. Registered October 9th. Capital, £100, 1s. shares. To take over the business of engineers and manufacturers of engines, being a portion of the business carried on by A. Richmond and T. T. Ranking, C.E., B.Sc., M.I.M.M., and M.I.M.E., at 81, Cannon Street, E.C., together with the benefit of the experiments made and method of constructing engines adopted by the proprietors of such business, and an option to purchase the English Patent Rights applied for No. 14,094, dated Oct. 4th, 1916, when and if granted. Directors: A. Richmond and T. T. Rankin (both permanent). Qualification, 500 shares. Registered office: 81, Cannon Street, E.C.

AIRCRAFT TRANSPORT AND TRAVEL LTD. (145,007).—Private company. Registered October 5th. Capital, £50,000, £1 shares (25,000 5 per cent part preferred). Manufacturers of and dealers in aeroplanes, balloons, airships, and flying machines of all kinds, etc. Directors: G. H. Thomas (managing director) and A. F. Thomas. Qualification, £100. Secretary: J. C. Soames. Registered office: 47, Victoria Street, Westminster.

NAVARRO AIRCRAFT CO. LTD. (145,030).—Private company. Registered October 9th. Capital, £2,000, £1 shares. Aircraft builders, electricians, mechanical engineers, etc. Registered office: 10, Essex Street, Strand, W.C.

S.P.A.R. MANUFACTURING CO. LTD. (145,018).—Private company. Registered October 6th. Capital, £1,000, £1 shares. Ironfounders, mechanical and electrical engineers, manufacturers of agricultural implements and other machinery, tool and boiler makers, etc. Directors: L. A. Wharrad and T. F. Cund. Qualification, five ordinary shares. Registered office: 5, Peakman Street, Redditch, Worcestershire.

# Queries and Replies.

We shall at all times be pleased to help our readers out of their difficulties to the best of our power, and invite them to make use of this column for that purpose.

Furring of Pipes.—Can you tell me through the columns of your most useful and informing pages why feed pumps fur up and get out of order in working? The feed supply is heated in the usual way, and a preparation is put into the boilers which keeps them quite clean and is a liquid without undue chemicals. A friend of mine suggests the pumps are affected when the feed water is over a certain temperature. When the fluid in question is passed through the injector or donkey pump it does not affect them, but my feed pumps are constantly a source of trouble.—J. B., London.

The deposit which "furs up" boiler feed pipes and pumps consists mostly of the carbonates of lime and magnesia bonded together often by a little of the crystalline sulphate of lime which is much more soluble in water than the carbonate of lime. The latter can only exist in solution in feed water in the presence of carbonic acid gas ($CO_2$). When the carbonate acid is removed by any means, such as by the introduction of an alkaline caustic—*i.e.*, caustic soda or caustic lime, the carbonate of lime is precipitated as a white amorphous powder.

Boiling produces the same effect by driving off the carbonic acid gas. Hence when the feed supply is heated the effect is to cause the lime salts to accumulate in the pipes and pumps.

Most liquid preparations for preventing scale contain caustic soda or potash. If such preparations are introduced into the feed supply, they would cause the furring up in the pumps and pipes by throwing down the lime salts before reaching the boilers, which would thus be kept free from scale.

Soda ash—*i.e.*, the carbonate of soda, has the effect of converting the soluble sulphate of lime in the water into the soluble carbonate, which is precipitated and causes "furring" of the pipes in the same way.

When the injector is used for feeding, it drives the feed water and the salts with which it is charged straight into the boiler, and the donkey pump is also probably quite close to the boilers.

Where there is a considerable quantity of carbonates, however, injectors are found to choke up very frequently.

The only really satisfactory and scientific mode of treatment is to remove the whole of the lime and magnesia salts by external treatment—*i.e.*, by a water softener before sending the water to the boilers.—W. J.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS.

**September 18th to October 4th (inclusive).**

Ahlberg, G. A. F.: Carburettors. 13,360.
Aktiebolaget Svenska Kullagerfabriken: Ball bearings. 13,307.
Alltree, A.: Change-speed gearing. 13,392.
Anschutz & Co.: Dynamo-electric machines. 13,443.
Acetylene Illuminating Co.: Storing gases under pressure. 13,676.
Addyman, E. T. W.: Internal-combustion engines. 13,667.
Alexander, G. H.: Carburettors. 13,818.
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Bachelet, E.: Electro-magnetic engine. 13,812.
Barton, T. A.: Fuel supply for motor-vehicles. 13,864.
Boot, G. H.: Rotary pumps. 13,817.
Bosch Magneto Co.: Magneto dynamos. 13,888.
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Bridge, R.: Lubrication of aircraft engines. 13,907.
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Maude, F. N.: Utilisation of centrifugal forces. 13,365.
Maude, F. N.: Generating power. 13,408.
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Murphy, W.: Economising spelter plates in boilers. 13,550.
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O'Gorman, M.: Multiple vacuum valve. 13,382.
Outerbridge, C. N.: Internal-combustion engines. 13,748.
Paterson, R. H.: Steam-traps. 13,885.
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Rendall, A. R. A.: Self-winding spring motor-starter. 13,716.
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Smith, E. C. Bowden-: Stop valves. 13,373.
Soc. Anon. Astra: Power-transmission apparatus. 13,213.
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Summers, N. R.: Driving-belt or clutch striking-gear. 13,679.
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Taylor Ltd., G.: Wince pulleys, &c. 13,534.
Tilston, E.: Internal-combustion engines. 13,348.
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Tyldesley, F.: Grease-cup lubricators. 13,781.
Veulle, F. H. de: Liquid-fuel feed systems. 13,468.
Veulle, F. H. de: Carburettors. 13,530.

VOGEL, H. B.: Clutches. 13,908.
WHIDDINGTON, R.: Multiple vacuum valve. 13,382.
WILSON, A.: Piston ring. 13,397.
WOODESON, W. A.: Distributing actuating-fluid in engines. 13,350.
WRIGHT, E.: Motor engine. 13,460.
WILKES, W. T.: Apparatus for using mixed or heavy fuels. 13,680.
WILKS, A. H.: Internal-combustion engines. 13,547.
WOLLATT, G. S.: Elastic-fluid turbines. 13,739.
WRIGHT, D.: Liquid-fuel-heated furnaces. 13,548.

## COMPLETE SPECIFICATIONS ACCEPTED.

**1914.**

2,500—STEVEN: Agglomerating coal and the like.

**1915.**

9,202—MATTHEWMAN: Valves.
12,098—COLE, MARCHENT, & MORLEY LTD., BRAILSFORD, & SPOONER: Air-supply regulating-devices for internal-combustion engines.
13,408—CLOUGH: Carburettors.
13,480, 13,482, 13,483, 13,484—HEYS: Dynamo-electric machines.
13,561, 13,562—SCHROEDER: Dynamo-electric machines.
13,579—DICKSON: Propellers.
13,792—HAURY: Gas-engine slide valve mechanism.
14,156—SANKEY & SMITH: Roller bearings.
14,341—GILL: Gear-boxes.
14,668—PRICE: Gas-fired furnace.
14,976—WILLANS, LUARD, & O'DONNELL: Feed-water heating-apparatus.
15,546—FUNCK: Internal-combustion engines.
15,618—HOWARD: Valve-mechanism.
16,026—BOND: Consuming smoke in steam-boiler and like furnaces.
16,269—WHITE: Method of operating coal-gas plants.
16,746—DOYLE: Liquid-fuel supply arrangements.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

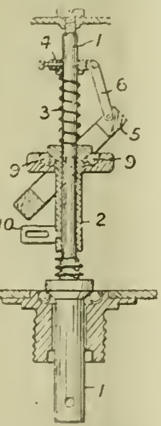
**1916.**

1,460—TYE, J. P.: Fire-bridges for boiler furnaces. **101,493.**
1,580—SEABURY, H.: Power transmission and reversing gearing. **101,436.**
2,158—BAYLIS, A. S.: Lubrication of internal-combustion engines. **101,504.**
4,349—SCHMID, A.: Apparatus for spraying liquid fuel. **101,510.**
5,129—JANSEN, J. HASSEL-: Supplying air to furnaces for consuming smoke. **101,446.**
5,526—NEULAND, A. H.: Dynamo-electric machines. **101,447.**
6,681—WALKER, J. R., and WALKER, A. E.: Oil engines. **101,451.**
7,317—BENNIS, A. W.: Furnace fire-bars. **101,454.**
7,705—ROYCE, F. H., DAY, B. I., and ROLLS-ROYCE LTD.: One-way friction clutch. **101,521.**
8,754—IGRANIC ELECTRIC CO.: Controlling and regulating electric motors. **101,523.**
11,929—SVENSKA TURBINFABRIKS AKTIEBOLAGET LJUNGSTROM: Lubrication of pressure-fed bearings. **101,528.**

## ABSTRACTS OF SPECIFICATIONS.

### SPEED INDICATORS.

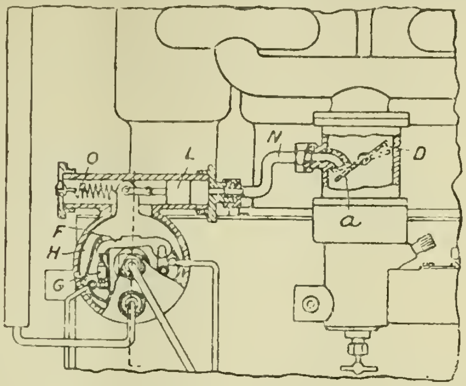
101,064.—D. MCNEILL, 131, Durban Road, Watford, Hertfordshire. April 6th, 1916, No. 5,086.—In centrifugal speed indicators of the kind wherein a governor operates the indicator through a non-rotating sleeve, a directly-driven shaft 1 has mounted thereon a sleeve 2, upon which is supported by a ball bearing a collar 9 pivoted to the ring governor 5. A link 6 connects the governor




to the shaft, and a spring 3 is interposed between the sleeve and a collar 4, to which the link 6 is pivoted. Rotation of the sleeve is prevented by a slotted lug 10 secured to the toothed sector, which operates the indicator in the manner described in Specification 13,841/15. The shaft 1 is carried by a ball bearing, and the two rods carrying the indicator described in the above-mentioned Specification may be replaced by a slotted hollow rod.

### INTERNAL-COMBUSTION ENGINES.

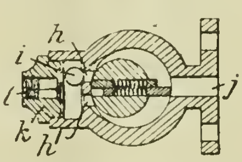
101,070.—W. O. KENNINGTON, 244, Parker Avenue, Detroit, Michigan, U.S.A.—April 18th, 1916, No. 5,680.—Apparatus in which a fall of pressure in the induction pipe automatically advances the ignition upon increase of speed is provided with means for automatically retarding the ignition when the engine is idling. The plate H carrying the timing contacts F G is rotated against the action of a spring O by the piston L, which is in communication with the induction pipe. Under the high suction which obtains while the engine is idling the throttle vale D either moves to obstruct the opening of the pipe N, or moves beyond the opening so that the piston L is not subject to the increased




suction. In the former case a small perforation puts the pipe N in communication with the outer side of the throttle. The throttle D may be linked to a valve in the pipe N, the throttle and valve closing synchronously. The device may be combined with a centrifugal governor for adjusting the cam for operating the contacts F G.

### ROTARY PUMPS.

101,071.—SELSON ENGINEERING CO., 85, Queen Victoria Street, and H. GOODWIN, 403, Old Kent Road, both in London.—May 2nd, 1916, No. 6,265.—A reversible rotary pump suitable for supplying lubricants to machines having reversible motion is provided with an inlet port $j$ and two outlet ports $h\ h1$, one or the other of




which, acording to the direction of rotation, is automatically closed by a single ball or like valve $i$, the fluid being discharged through the open port into the outlet nozzle $k$, which is fitted with a bar $l$ to obstruct the entry of the ball $i$.

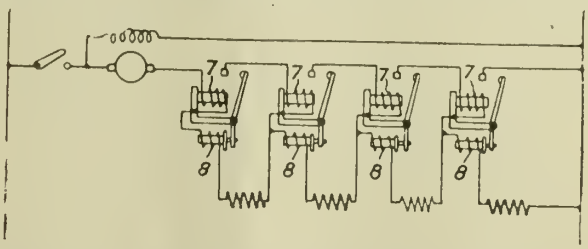
### BELT GEARING.

101,102.—J. YOUNG and R. M. YOUNG, Clarence Street, Bolton, Lancashire.—January 26th, 1916, No. 1,235.—In a fastening for driving belts comprising a number of eyes fixed to the belt ends and connected together by a cross-bar threaded through them, the eyes $a$ are formed on pins A of half-round section. The pin


may have two legs of equal length as an ordinary split-pin, or one leg may be cut off as shown, the flat surface of the other leg bearing on the belt. The end of the pin is passed through the belt and clinched.

### ELECTRIC MOTOR CONTROL SYSTEMS.

101,103.—IGRANIC ELECTRIC CO., 147, Queen Victoria Street, London (Cutler-Hammer Manufacturing Co., Milwaukee, Wisconsin,

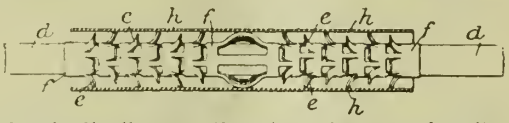



U.S.A.).—January 28th, 1916, No. 1,374.—Resistance contactors have operating and lock-out coils so arranged that each of the lock-out coils is included in circuit simultaneously with the completion of the motor circuit and remains in until cut out by its own

contactor. The arrangement is shown in Fig. 1 with series operating windings 7 and series lock-out windings 8. Each contactor remains open until the current in its lock-out winding has dropped to a predetermined value. In a modification, the last contactor short-circuits all the windings 7 8 and is held closed by a coil shunted across the mains.

### INTERNAL-COMBUSTION ENGINES.

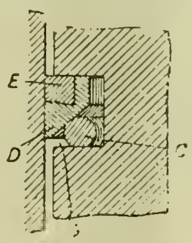
101,111.—A. GRAY, 32, Taff Mead Embankment, Cardiff, J. GASKELL, White House, Llantwit Major, and W. T. WILKES, "Olveston," Clinton Road, Penarth, all in Glamorganshire.—February 28th 1916, Nos. 2,934 and 5,392.—On the induction pipe *d* is mounted either a series of rings with radiating helical ribs *c*, Fig. 1, or


a pipe *f* slit longitudinally and the pieces between the slits bent outwards as shown in Fig. 4. The ribbed pipe is surrounded by a tube *h*, which is contained in a branch *a* of the exhaust pipe with insulating air spaces *i* between them.

### PISTON PACKING.

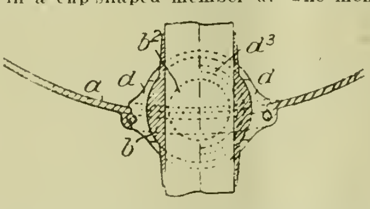
101,113.—N. E. BROOKES, 55, Chancery Lane, London (A. Goodwin, United States).—March 20th, 1916, No. 3,219.—Piston packing, particularly applicable to the pistons of internal-combustion engines, consists of a split ring D of less width than the containing groove G, with a bevelled surface acted on by an expanding




ring C. The latter ring is of rounded section with a flat surface bearing on one side of the groove G. Preferably the ring D is normally of the same diameter as the cylinder bore. The ring may be recessed to receive a second split ring E, the recess being undercut to prevent undue expansion of the ring E.

### STUFFING-BOX SUBSTITUTES.

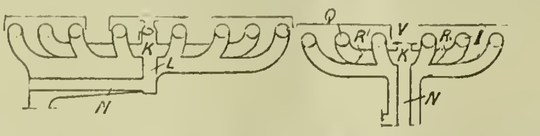
101,115.—E. T. W. ADDYMAN, The White House, Starbeck, Harrogate, Yorkshire.—March 14th, 1916, No. 3,808.—In an internal-combustion engine in which the front end of the cylinder is separated from the crank case by an oscillating plate *a*, the joint between the piston rod and the plate comprises a member *b* which turns in a cup-shaped member *d*. The member *b* has pro-




jections *b*2, or projections *b*2 and annular projections *d*3, which engage recesses in the cup-shaped member *d*. Alternatively, the projections may be on the member *d*, and the recesses in the member *b*. The member *d* may be dispensed with. A modification is described in which a flat plate *a* is used.

### INTERNAL-COMBUSTION ENGINES.

101,132.—G. C. C. HENDERSON, 360, Wells Road, Knowle, Bristol.—May 9th, 1916, No. 6,648. Addition to 21,620, 1914.—In the vaporiser described in the parent Specification, the vaporising tube is lengthened by omitting the mixing chamber and providing an air inlet in the induction pipe, throttle valves being fitted




between this air inlet and the cylinder ports. The vaporising tube N may be arranged vertically or horizontally, as shown respectively in Figs. 3 and 4, being connected, in the latter case, with the induction pipe K by a passage L. The air inlet is shown at V, and throttle valves for the cylinder ports I Q at R R1.

# INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

VOL. V.] NOVEMBER 8TH, 1916. [No. 122.

## The Industrial Engineer.

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## CONTENTS.



# EDITORIAL.

### Shipbuilding.

If there is one industry more than another in which we Britishers pride ourselves, as becomes an island nation, it is that of shipbuilding. Here, at any rate, the voice of the carping critic is absolutely snowed under. Self-depreciation of our attainments, so common amongst a certain class of journalists and self-styled economists, has no show of any kind when dealing with the subject of shipbuilding. In this industry we stand, and are likely to stand pre-eminent, whether it be in ships for the carrying on of peaceful trade or in those destined for use in a destructive war such as we are now experiencing. Notwithstanding the progress which has been made by some of our competitors, it must be self-evident to the merest tyro that our shipbuilding community are in possession of an almost unfathomable fund of experience which has been handed down from father to son, which is practically unattainable by our competitors strive they never so well.

### Effect of the War.

The war has certainly had an effect on production, at any rate, so far as merchant ships are concerned, and this, combined with the destruction effected both upon our own and Allied and neutral merchant fleets, has caused a large shortage of tonnage which will take some little time to replace. As a result of this shortage and the enormous demands made upon our carrying capacity by the requirements of our own and Allied war services and the entire removal of German and Austrian ships from the sea, the building of ships has been stimulated in every country free to engage in the industry. Naturally, in our own case the production of war vessels has paramount attention at present to the inevitable detriment of the merchant service, but it should be remembered that our building equipment has and is being increased enormously by the augmentation of plants existing at the commencement of the war and by the establishment of new slipways, so that it must be plain to see that the possibilities of production at a greatly accelerated rate is one of the first things that will occur on the declaration of peace.

### In Neutral Countries.

In these, and particularly in the United States, plants are being augmented and new establishments created to cope with the demand for tonnage. Lloyd's Register of Shipping states that there is now being built under their inspection a larger amount of shipping than has ever been recorded in the history of the society, namely, 620 vessels of 2,282,709 tons.

### Building During 1915-16.

It is interesting to note that for the year ended June 30th last 10,032 merchant vessels, registering over 23 million tons gross, held classes assigned by the committee of Lloyd's Register. These figures, large as they are, show a falling off from the high-water mark of the previous year, thus reflecting the heavy losses which have been occasioned by the war. During the year under review the committee passed the plans of 742 vessels, representing 2,375,590 tons of shipping, to be built under the society's survey with a view to classification in Lloyd's Register Book, as compared with plans of 733 vessels of 1,713,500 tons for the previous 12 months. The committee assigned classes to 362 new vessels of 790,209 tons, of which 356 were steamers, or motor vessels, of a tonnage of 789,688, and six were sailing vessels of 521 tons. Of the total 414,462 tons, or about 52½ per cent, were built for the British Empire (United Kingdom 397,852 tons, Dominions 16,605 tons) and 375,747 tons, or about 47½ per cent, for other countries,

# THE USE OF POWDERED COAL IN METALLURGICAL PROCESSES:

## A DISCUSSION OF THE ENGINEERING PRINCIPLES INVOLVED.

By C. J. Gadd.

(*Continued from page 27.*)

### Feeders and Burners.

Powdered-coal feeders are of two kinds—one type consisting of a mechanically-operated screw or flight conveyor having a variable feed, the other type consisting of a syphon, through which the fuel is fed by the medium of compressed air, the feed being regulated by the air-pressure.

Burners for powdered fuel are operated under either low or high pressure. Low-pressure burners are used with an air blast varying from two ounces to eight ounces. High-pressure burners are used with compressed air varying from 40 lbs. to 100 lbs. pressure.

Fig. 3 illustrates a sectional elevation of a mechanically-operated low-pressure feeding apparatus for coal dust, also a sectional view of the feeder taken across the air-blast ports, showing the method of its connection with the burner.

By referring to the sectional elevation it will be noted that from the hopper the horizontal conveyor screw delivers a stream of coal in the direction of the arrow mark, which falls as a continuous shower past the air-blast ports, and is picked up by a cross-stream of air, which delivers the mixture through the coal-delivery pipe to the burner.

The quantity of fuel delivered by the conveyor screw is regulated by varying the speed of rotation, which in this case is obtained through a direct connected variable-speed motor. The amount of fuel taken up by the cross-current of air will vary with the pressure of the air blast, which is controlled by a suitable valve placed in the blast line. Any excess fuel escaping the feeding action of the air blast is automatically returned to the hopper by the lower inclined conveyor screw.

The coal-delivery pipe discharges its mixture into the burner, the low-pressure inlet pipe furnishing the necessary additional air for combustion, and the resultant mixture is discharged into the furnace.

### Low-pressure Feeding Apparatus.

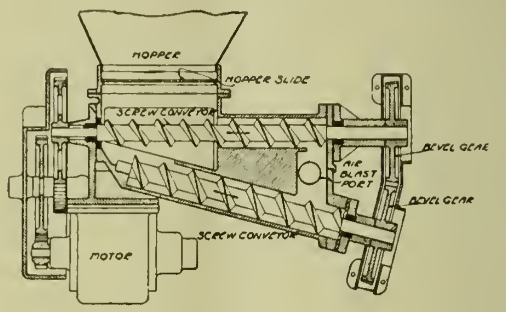
Fig. 4 shows a sectional elevation of a mechanically-operated low-pressure powdered-coal feeding apparatus, also a sectional view of the feeder taken across the air-blast ports, showing the method of its connection with the burner.

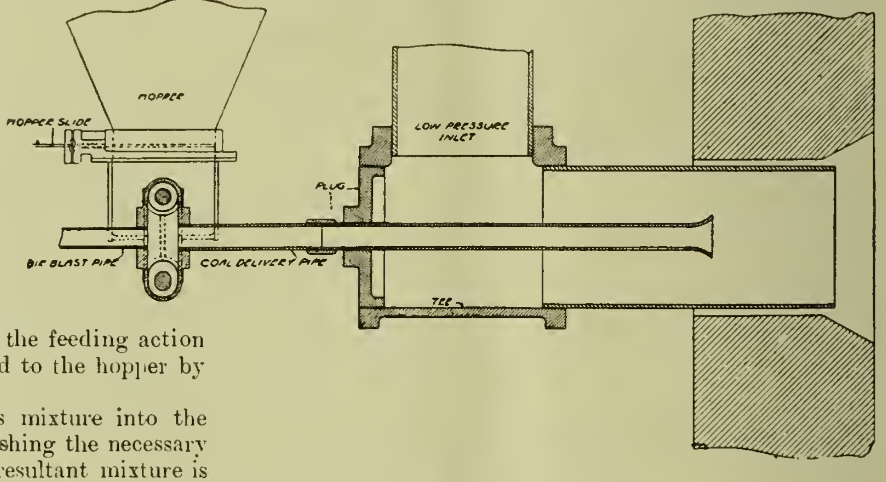
By reference to the sectional elevation it will be noted that in this device an endless flight conveyor chain is used for feeding a stream of powdered coal in a continuous shower across the air-blast ports, and the excess fuel escaping the feeding action of the cross-current is automatically returned to the hopper by the endless flight conveyor chain.

Variable fuel feed is obtained through a direct connected variable-speed motor, and the amount of fuel taken up by the cross-curent of air will vary with the pressure of the air blast.

The air-blast inlet nozzle connecting with one side of the feeder case is reduced, the outlet side being flared, beyond which is a Venturi tube used to induce higher velocity of the mixture leaving the feeder, thereby causing a slight vacuum or pull throughout the case, the mixture continuing through the coal-delivery pipe to the burner. The cone extension on the hood of the burner enters the flared end of the coal-delivery pipe, breaking the solid shaft of coal and air and deflecting it around the inner periphery of the burner pipe. The mixture takes the form of a hollow ring, in the centre of which an auxiliary blast is discharged, giving a very thorough atomization of the particles as they enter the furnace.

Figs. 3 and 4 serve to illustrate two forms of low-pressure mechanical feeders and burners in commercial use, modifications of which are also in successful operation, all involving the same general principle, namely, a mechanism which will give a uniform and properly proportioned mixture of coal and air, both under variable control, feeding the resultant mixture in a thoroughly atomised state into the furnace.



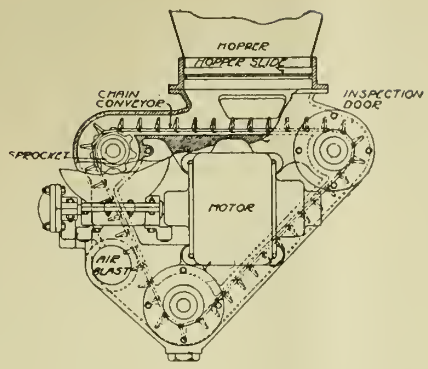

The Use of Powdered Coal.—Fig. 3.

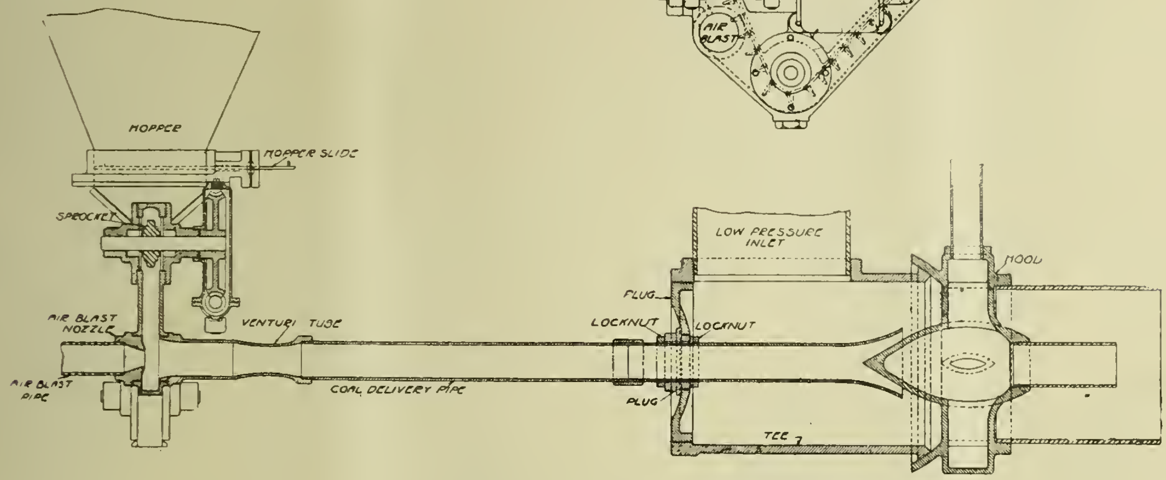
Feeders and burners of this type are used almost exclusively on the many forms of heating furnaces in the metallurgical arts. This method of burning powdered coal with low velocity of both air and coal produces a short flame, as the fuel combusts almost the instant it leaves the burner, and heat thus produced is conveyed by the gases from the initial point of firing with less cutting action upon the material being heated and on the brickwork.

Powdered coal will flush, and when once started will run like water. Screw feeding devices should, therefore, be made very long and of a reasonably fine pitch in order to set up enough friction and baffling action to prevent the coal from flushing through the feeding mechanism and causing irregular feed.

In the case of the feeding mechanism shown in Fig. 3, long screws would make a cumbersome and expensive device, and efficiency has been sacrificed in this form of feeder for the sake of compactness and cost, as feeders of this design in use at present will invariably flood. They have another very

objectionable feature, namely, if the air blast is not turned on the feeder started up the screws will jam so hard that the motor is stalled The arrangement of the inlet and outlet blast through the feeder case sets up a pressure in the feeder, the result being that it not only tends to arch the coal in the bin, but it blows the coal out of the bin or the feeder case, wherever a leak may occur. In addition, under normal running it consumes considerable power to operate.




THE USE OF POWDERED COAL.—FIG. 4.

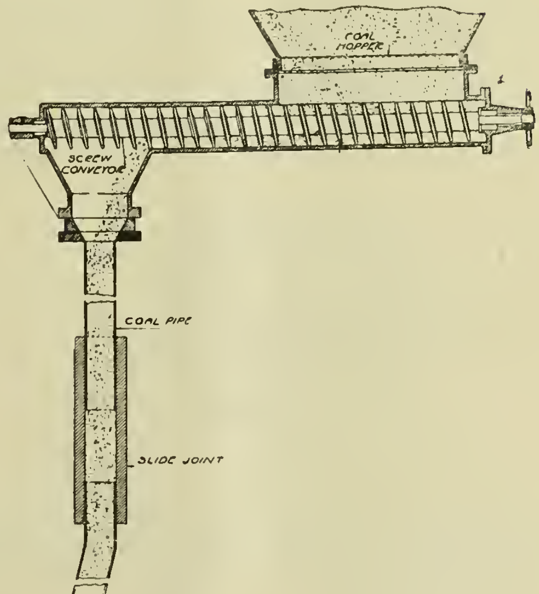
In Fig. 4 the vertical flights and the conveyer chain have a baffling action which prevents flooding. Under operating conditions it has been proved that the coal will not pack in the feeder should the air blast be cut off. The air-blast nozzle and Venturi tube, producing a suction through the case, have a tendency to prevent arching in the hopper, thus giving a more reliable and uniform feed. In addition, this suction prevents leakages as there is always an inward pull on the case. This type of feeder takes one-tenth of the power to operate it as compared with the same capacity of screw-feeding device shown in Fig. 3.

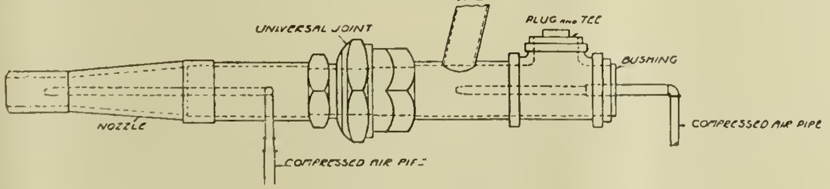
## High-pressure Feeding Apparatus.

Fig. 5 shows a sectional elevation of a mechanically-operated high-pressure powdered-coal feeding apparatus. By reference to the drawing it will be noted that in this device a long screw of fine pitch conveys the coal from the hopper and discharges a uniform stream of powdered fuel into the coal pipe. This stream falls by gravity down the coal pipe and is picked up by a cross jet of compressed air as it enters the burner. The expansion of the compressed air in the larger diameter of the burner thoroughly mixes the coal and air, and this mixture is injected from the burner into the furnace at high velocity by the compressed air jet at the end of the nozzle.

By varying the speed of rotation of the conveyor screw variable fuel feed is obtained.

*(To be continued.)*




THE USE OF POWDERED COAL.—FIG. 5.

MESSRS. THE PATERSON ENGINEERING COMPANY LTD., water purification specialists, of India House, Kingsway, London, W.C., advise us that their premises in India House, as above, have been requisitioned by the Government. Those of our readers interested in up-to-date appliances for the purification of water supplies should write for their new catalogue, 1916, which has just been issued. We are asked to state that their temporary address is Windsor House, Kingsway, London, W.C.

NEW COAL DEPOSITS.—A Norwegian expedition which has just returned from Spitzbergen has discovered important new coal deposits in the eastern districts, near Green Harbour, Advent Bay. The deposits are reported to consist of two seams at different depths, one of them from 6 ft. 6 in. to 10 ft. thick. It is estimated that they contain about 1,000,000,000 tons of first-class coal. Plans are being worked out for erecting a mining plant capable of producing 200,000 tons yearly.

## EVOLUTION IN VENTILATION HYGIENICS.

By James Keith, A.M.I.C.E., M.I.M.E., M.I.Mar.E., Etc.

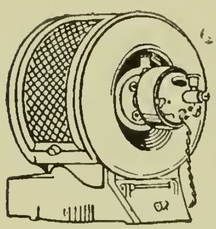
*(Continued from page 33.)*

### 3.—POSITIVE, SO-CALLED NATURAL, AND NEGATIVE VENTILATION.

#### Positive Ventilation.

Positive ventilation on a somewhat similar principle to the foregoing, but obtained by the use of different arrangements, appears also to be the best means for furnishing fresh air with comfort for ordinary life in private offices, rooms, railway carriages, state-rooms, etc., and this may be most efficiently attained by the use of electrically-run mechanical ventilators of the forms shown by Figs. 6, 7, and 8, applicable to windows, columns, etc.

In various cases under consideration, fresh air is drawn direct from the outside by a small-size open fan (either of single or double air inlet), driven by an electric motor, the air being propelled into the apartment through a comparatively large area of fine wire gauze in such fine streaks that good ventilation may be obtained with an entire absence of draught discomforts.



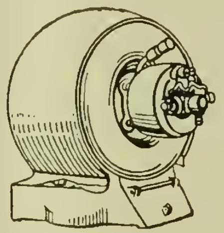
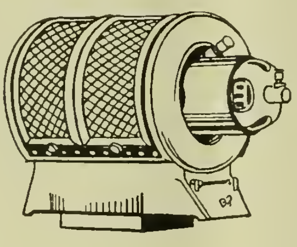
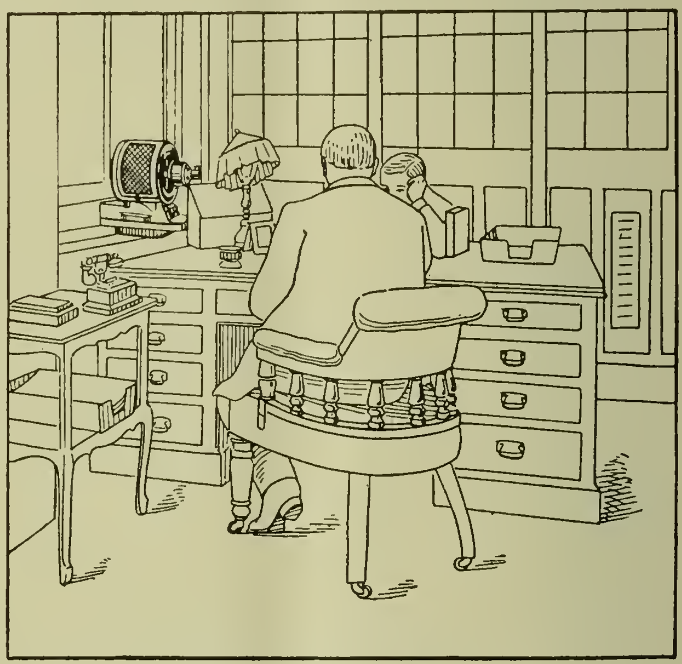


Fig 6.—Ventilation Hygienics.—Fig 8.



Ventilation Hygienics—Fig. 7.



Ventilation Hygienics—Fig. 9.

When the ventilators are fitted with fog filters, as in Fig. 8, pure air, free from fog or other deleterious matter, may be poured into any apartment. These electrically-run ventilators are noiseless when the motors do not exceed 1,200 revolutions per minute, and give a volume of air fully sufficient for ordinary room ventilation. When installed upon the window sill of a bedroom, or of an office, as in Fig. 9, the ventilator will give over 6,500 cubic feet of fresh "live" air every hour without discomfort from draught, requiring for its operation but 24 watts, or 0·8 carbon 8 candle power incandescent electric lamp current, with the motor running not more than 1,200 revolutions per minute.

In the case of a room, say, 18 ft. in length by 16 ft. in width and 11 ft. in height, having an open fireplace or chimney exit and two windows, one of these plenum units, installed as in Fig. 9, in each window, will ensure a complete change of air to the extent of 13,000 cubic feet per hour, or fully four times the whole cubical contents of the room, with an expenditure of electrical current (equivalent to 1·6 candle power incandescent electric lamp) of 48 watts. Where a certain degree of noise may be permissible (say, in workshops, railway carriages, etc.), over three times the amount of air may be obtained from the same size of apparatus by the use of a larger motor running at higher speed with an increased expenditure of electrical current.

The window ventilator may also be provided with a fine gauze rainproof screen or filter on the air inlet outside to screen the air from dust, flies, etc., before it enters the apparatus.

#### Natural Ventilation, So-called.

Natural ventilation appears to be quite a misnomer, as it can only naturally be obtained in the open or outside all artificial surroundings. The term is very often erroneously applied to the ventilation obtained in ordinary rooms by the use of an open fire, which method of ventilation again is solely secured by the expenditure of energy in the burning of fuel in the grate, which heats up the chimney and causes an induced draught from the room.

Dr. George Reid states that: "The chief forces acting in nature which encourage ventilation are (1) diffusion; (2) the action of the winds; and (3) the movement produced by unequal weights of air, upon which principle the wind itself is dependent."

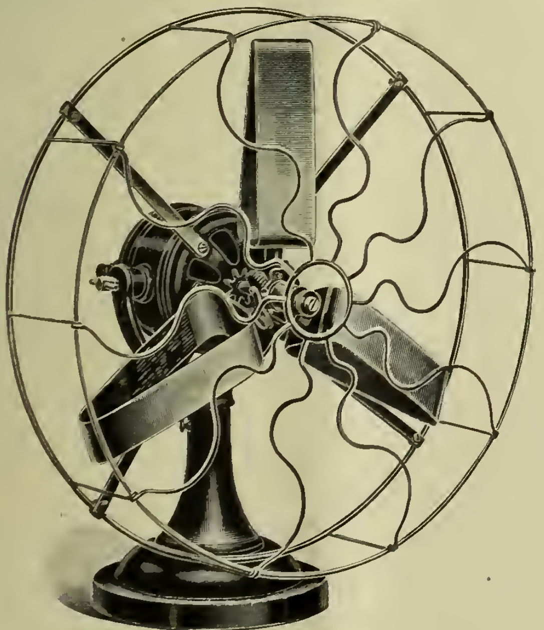
So far as the present dissertation is concerned, the first two forces named may be eliminated, while the third force only applies to buildings or rooms heated in cold weather, as any suction power inside such buildings or rooms is gained solely by the difference of temperature between the air within and that without, while in summer time, or when the air may be warmer outside than inside the buildings, the air current may be all the other way.

**Negative Ventilation.**

What may be called negative ventilation is to be distinguished from positive ventilation of rooms or enclosed places by the stirring or moving of the inside air continuously, intermittently, or otherwise by punkahs or fans in various forms.

Ventilation Hygienics—Fig. 10.

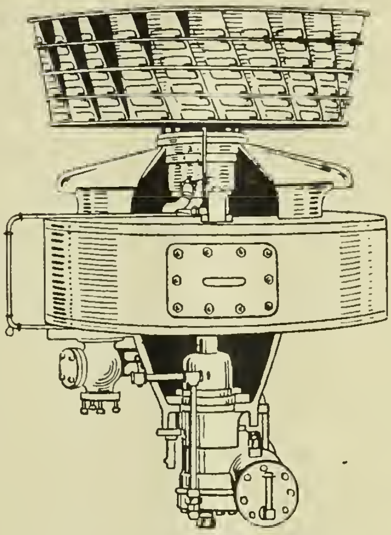
Nowadays, this desirable movement of the air may best be obtained by means of light electrically-driven fans placed on brackets on the walls, hung from the ceiling, or placed on desk tops in apartments in which the air is to be agitated without causing inconvenience.



Ventilation Hygienics—Fig. 11.

Undoubtedly the most effective appliances for this purpose are what are called intermittent electric fans, as illustrated by Figs. 10 and 11.

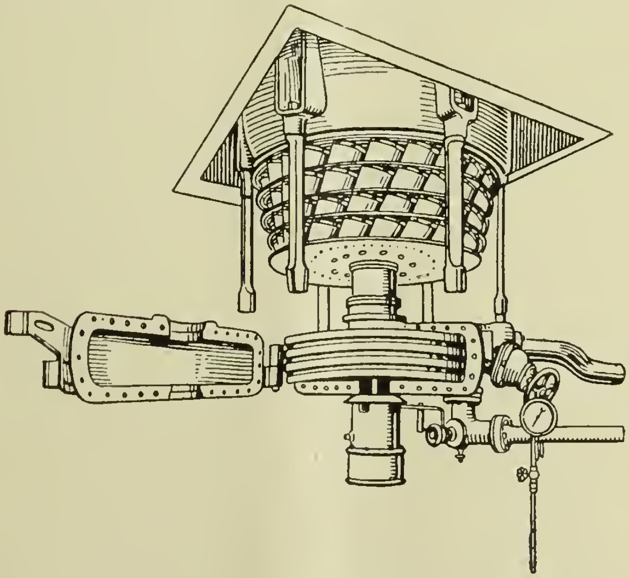
By the use of special fans, the blades of which alter their inclination or position automatically, an air current at a relatively low speed, rising and falling in strength, is obtained intermittently in one direction or in two directions alternately, and that quite noiselessly and at a very small cost for electric current, thus overcoming the "uniformity of atmosphere" so prejudicial to good health.



Ventilation Hygienics—Fig. 12.

## 4.—FORCED DRAUGHT FOR WAR VESSELS.

The relatively high speed at which torpedo-boat destroyers have now to run has, particularly because of their being fitted with tubular oil-fired steam boilers, necessitated the adoption of special turbo-fans to give the exceptionally high water-gauge air pressure necessary in closed stokeholds. Fig. 12 shows the form of turbo-fan now in use in the British, United States, and Japanese torpedo-boat destroyers, while Fig. 13 illustrates the form adopted in the Italian destroyers.



Ventilation Hygienics—Fig. 13.

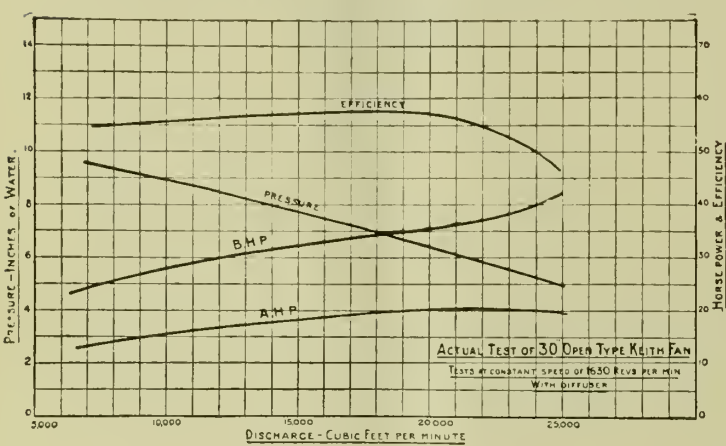
It will be noted that in all four cases the fans are of the same type and construction—*i.e.*, open fans of similar type to those shown in the preceding diagrams, but strengthened to stand the increased centrifugal stress of the higher speeds,

although the direct-driving steam impulse turbines used in the Italian destroyers are different from those used in the British, United States, and Japanese destroyers.

These open fans, or impellers, are never less than 30 in. in the inlet diameter, and run at an average speed of from 1,500 to 1,600 revolutions per minute, according to size of impeller, and each delivers from 20,000 to 25,000 cubic feet of air per minute against a static water gauge in stokehold of 6 in. pressure with an efficiency of the best type of cased fan. By virtue of the vertical arrangement air is distributed high up in the stokeholds, where the pressure equalises itself, thus avoiding unequal air distribution to the oil burners and the formation of eddies which would set up draughts and cause discomfort to the occupants of the stokeholds.

There have been published elsewhere diagrams indicating by stream lines the approximate course followed by the air when passing through the impellers.

As might be expected, the stream lines show a continuous course with no sudden changes in direction, so that the




Ventilation Hygienics—Fig. 14.

actual course of the particles of air may also be regarded as steady, a result which is corroborated by the characteristic and efficiency curves shown by Fig. 14. These curves show the results of a test carried out by the American Government experts at the Annapolis Naval Academy at a constant speed of 1,630 revolutions per minute, the outlet areas being gradually enlarged to show the falling pressure with increase in volume. The lower curve shows the actual air horse power, the next the actual brake horse power absorbed, the pressure volume curve shows the fall in pressure with increase in volume, and the efficiency curve based on the air horse power divided by the brake horse power.

The curves are intended to show the pressure volume characteristic at constant speed, and show a maximum efficiency of 57·5 per cent.

*(To be continued.)*

Explosibility of Acetylene.—A paper on the explosibility of acetylene, issued by the Bureau of Mines, Washington, states that experiments showed that the smallest proportion of acetylene capable of propagating flame in a mixture of acetylene and air was 2·53 per cent. The largest proportion of acetylene capable of propagating flame in a mixture of acetylene and air was found to be about 73 per cent. Acetylene not mixed with air is explosive under a pressure of three to five atmospheres when an electric spark is passed through and when a platinum spiral is heated in it. The danger connected with the handling of calcium carbide in a mine is remote if reasonable care is observed in handling.

## SHORT CIRCUITS.

By F. Ashton.

*(Continued from page 35.)*

### A New and Interesting Scheme.

Latterly, a new and interesting scheme has been brought to light which is being adopted on the large power and lighting systems in America. Reactance coils, which limit the generator current at times of short circuits to about 10 or 12 times the full-load current, are connected in the leads which conduct the current from the alternators to the bus-bars. These reactances are capable of standing the maximum current that is likely to pass into the system, and it has been found that in medium-sized stations, say, of 60,000 H.P., the short circuit current can in this way be limited to a safe amount. A 60,000 H.P. station might, in the absence of current-limiting reactances, produce at the instant of short circuit as much as half a million horse power, for the stored energy in the machines is very great, but with reactance coils in the generator leads, the momentary output might easily be limited to about 150,000 horse power. Not only have American engineers introduced reactances into the generator circuits, but also in feeder and transformer circuits and between sections of the bus bars. The latter scheme, however, has been found only to be necessary in the case of the largest systems. With reactance coils connected between sections of the bus bars, the conditions at times of short circuits approximate those that prevail when the generators in a station are operated in two or more groups, although, of course, the generators that are not connected to the particular section that is short circuited are still capable of contributing a certain amount of current to the fault. The reactance coils between the bus-bar sections do not in any way interfere with the parallel working of the machines, but they limit the flow of current from one bus-bar section to another. It is possible, by connecting these reactances in series with portions of the bus bars and in feeders and generator leads, to run the largest plants with much less risk than hitherto. A short circuit seriously affects only one section, and the destructive effect is limited to the power of the generators on that section plus the limited power that can flow from the two adjoining sections. Large generating stations can in this way be divided into sections each of about 60,000 horse power. At times of short circuits, the maximum power that has to be dealt with can be kept within 150,000 or 200,000 horse power, which can be handled by specially-constructed oil circuit breakers. There is therefore no difficulty in the way of extending electrical systems to any desired degree, especially when reactance coils are connected in feeder and generator circuits, as well as between sections of the bus bars. But it is not always necessary to use reactances in every generator or feeder circuit, or even between sections of bus bars. Much depends upon the type of generator.

### Use of Reactances Demands Experience.

The discriminate use of reactances demands experience. So far as this country is concerned, separate reactance coils have not, up to the present, been necessary on most of our electrical systems. Compared with some of the largest inter-connected American systems, many of the public electrical plants in Great Britain are small and insignificant. Thirty thousand kilowatt sets have not at present been set to work in this country, nor have we any gigantic inter-connected systems. Still,

for a long time past the capacities of our stations have been increasing. Moreover, even during the present war there has been some progress in the direction of linking up. A time will undoubtedly come when greater attention will have to be paid to limiting short-circuit currents, for by connecting large plants together the destructive effects of short circuits are liable to be materially increased. It is easy to point to many inter-connected power schemes in America and on the Continent of Europe that are working without any artificial current-limiting arrangements at all, but, as a rule, the stations are hydro-stations, containing large slow-speed generators with inherent low short-circuit currents. Further, the transmission lines between these stations are sufficiently long to offer a fair amount of impedance, which checks to a certain extent the interchange of current. The lines act in a similar way to the reactance coils which are connected between the sections of bus bars.

### Reactance Coils.

Reactance coils for the protection of electrical plants are not, as a rule, provided with iron cores. While a few turns of wire surrounding an iron core will give the same reactance as many turns without such a core the former type of coil is sluggish in action. Two coils with iron cores of the same measured reactance, but differing in design, may behave very differently if one has a closed and the other an open circuit, and even the same coil with an iron core may give different results under similar conditions as a result of a difference in the residual magnetism. Further power-limiting reactances must retain their reactances at times of short circuits, which means that if iron be used in them the flux density must be such that at times of short circuits the saturation point must not be reached, and as a result the densities are so low that it is, as a rule, more economical to produce the field in air than in an iron core. Another advantage of reactance coils without iron cores is that there are no iron losses. Since short-circuit currents can be limited by increasing the internal reactances of generators, the question arises as to why it should be necessary to use independent reactance coils. The reason is that the provision of sufficient internal reactance in high-speed machines may interfere with economical design, and a further disadvantage is that inadequate protection may be afforded in the case of an internal short circuit. It is, therefore, better to give high-speed generators a reasonably high internal reactance in the leads. Reactance is expressed quantitively in so much per cent. If, for instance, a coil connected in series with a transformer is said to have a reactance of 4 per cent, it means that it is capable of absorbing 4 per cent of the voltage across phases. If, in order to reduce the short-circuit current of a generator to a safe value, it is necessary to increase the normal reactance, say, 8 or 10 per cent, this might be done by giving the generator a reasonably high reactance, say, 3 or 4 per cent, and by providing independent coils to make up the difference. Additional reactance can, of course, also be provided for in step-up and other transformers.

*(Concluded.)*

New Railways.—The Russian Government have plans for 25,000 miles of new railways, to be constructed within five years if possible. This will involve an expenditure on machinery of about £10,000,000 for the first year, while another £20,000,000 will be required for private lines.

## NIAGARA WIRE-ROPE WAY.

A passenger cable-way, said to have the longest clear span in the world, has recently been built across the Niagara Whirlpool, at a cost of about £15,000. The passenger car is suspended from a running gear which travels on six parallel track cables of 1 in. crucible steel rope. Each cable is anchored securely at Colt's Point, the starting-point, by means of a 2 in. rod bent into an anchorage in a 740-ton concrete block. At the other terminus each track cable passes over a sheave, and is fastened to a counterweight or stretcher. Boxes, 12 ft. high by 6 ft. 7 in. wide by 11 in. deep, made of riveted steel, contain cast-iron weights sufficient to make a total of 10 tons for each track-cable counterweight. The boxes move up and down freely in steel guides, maintaining the tension in each cable always at 10 tons, regardless of the load on the cables. When the load on the car is increased, the counterweights rise, and sag in cables is increased until they take such an angle that the sum of the vertical components of the tension at the ends is equivalent to the weight of the car and its load. Each track cable is entirely independent of the others. The breaking of any one of them would not be serious, as the other cables would support all the weight of the car without any increase in their tension. The car would drop several feet suddenly, and, after a few vertical oscillations, would assume a new position of equilibrium. Thus, the breaking of one cable would not imperil the passengers, and the breaking of two cables at the same time would be very improbable. The car seats 24 passengers, and provides standing room in a raised aisle in the centre of the car for 22 more, including the conductor. The weight of the car when empty is 3½ tons, and when fully loaded 7 tons. It is 10 ft. 10 in. wide, 24 ft. long, and 23 ft. high. The car is propelled by a ⅞ in. plough-steel traction cable fastened to one end. This cable passes over a sheave on Colt's Point, runs back across the whirlpool, over a sheave in front of Thompson's Point station, the other terminus, and to the driving sheave. From here it passes around three sheaves, to one of which is fastened a 10-ton counter-weight box, arranged in guides similar to those for the track cable counter-weights, thus creating a tension in the cable which adjusts any slack caused by the rising and falling of the car. The 8-ft. driving sheave is turned by a 75 H.P. Westinghouse motor, through a 30 to 1 worm-gear, giving a speed to the car of about 400 ft. per minute when the controller is at full speed. The trip can be made in about 4½ minutes, but it is planned to permit it to occupy six minutes by running at half-speed part of the time. To provide against a breakdown of the motor or interruption in the power supply, there is a clutch in the driving shaft, by means of which the motor can be disengaged and a 5 H.P. petrol engine engaged both through a worm and through socket wheels. An automatic control stop is provided in each terminal, which stops the car without jar within a distance of 3 ft. 4 in. The traction cable runs longitudinally through the 5-in. pneumatic cylinder and through the centre of the piston. A clamp on the traction cable, just ahead of the car, strikes the face of the piston and also engages with it in such a manner that the car cannot slip back from the landing platform. After the traction and track-tower sheaves had been erected, a very long rope was carried around the face of the cliff from Thompson's Point to Colt's Point. This rope was then hoisted over the tops of the trees until it could be pulled taut from point to point. A ½ in. wire rope was pulled across with the aid of a hoisting engine, and then the ⅞ in.

traction cable was pulled into place. The traction cable was used to haul the track cable across. The strength of the track cable is 92,000 lbs. each, allowing for bending over the sheaves, and the working tension is 20,000 lbs., so that the factor of safety is 4·6. The sag of the track cable unloaded is 47 ft. 6in.; the maximum sag when loaded with car and passengers is 100 ft. The car will still be 148 ft. above the surface of the water at the point of maximum sag. The grade of the track cable varies from 16 per cent at either landing to level at the centre of the span. The above description has been abridged from the *Canadian Engineer.*

## ELECTRIC LIGHTING IN TEXTILE MILLS.

The advantages of electric lighting in textile mills are so obvious that they have been generally recognised, and this system of illumination has been widely adopted.

The electric method of illumination lends itself, in its many modifications, to adaptation to the special requirements of the work in a factory, but some care is necessary in planning the installation if the best results are to be obtained.

There are two systems affecting the distribution of light, each of which has its advantages.

The first system, which may be called a "solar" system, involves the use of a comparatively small number of high candle power lamps equipped with reflectors and semi-obscured globes, which yield a general diffused light over a very large area. From the point of view of the worker, this system has the advantage of being less trying to the eyes than localised illumination which is difficult to provide without placing the lights where they come into the direct line of vision of the worker.

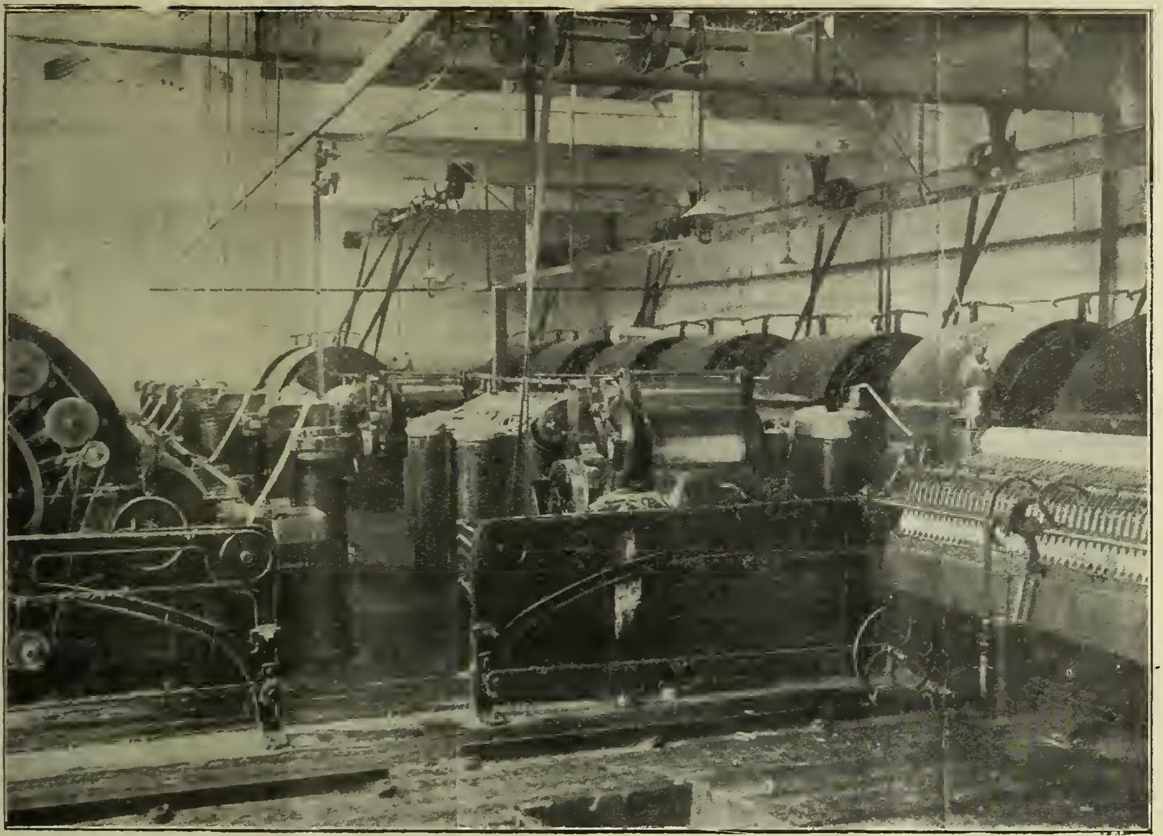
On the other hand, it is evident that a system which requires that the lamps shall be suspended at a considerable distance from the machine must give less local illumination unless the lamps are of relatively high candle power. A great deal of light falls where it is not needed, excepting so far as it contributes to a useful general lighting. By using Royal "Ediswan" ½-watt type lamps, the efficiency of which is double that of the smaller candle power lamps used for localised lighting, this drawback is to a great extent overcome. Where the buildings are lofty enough to allow of the lamps being suspended at a sufficient height above the floor, the system is perhaps the best which can be adopted.

In low buildings, or in cases where it is desired that a strong light shall be concentrated upon the machines, a larger number of comparatively low candle power lamps will give better results. This system may be called the

Electric Lighting in Textile Mills—Mule Room.

The Edison-Swan Electric Co. Ltd. have given special attention to the design and construction of all the fittings adapted for such installations, whether required for the spinning mills or weaving sheds.

The illustrations accompanying this article are of various mills where the instalment of electric lighting has proved a great success beyond a doubt in very many ways. It will be seen in some instances how the dust has thickly accumulated on the fittings, without in any way causing deterioration of the lighting, and at the same time not providing any special danger of firing, owing to a special type of holder which makes it impossible for the fluff to accumulate on the terminals.



Electric Lighting in Textile Mills—Card Room.

Electric Lighting in Mills—Weaving Shed.

"Stellar" system. A suitable unit of illumination is the 40-watt lamp with metal filament, which gives about 30 candle power. These can be suspended in spinning mills from the "roller beam," eight lamps being installed for each mule.

In weaving sheds two 40-watt lamps may be installed for each group of four looms.

The lamps must be strong enough to withstand considerable vibration, and the Royal "Ediswan" traction type of lamp, such as is used for tramcar lighting, is recommended for the purpose. The cost of these special lamps is not greater than those used for ordinary lighting.

Whichever system is selected to suit the conditions of each installation, the adoption of electric illumination is certain to add to the productive efficiency of the mill. The steadiness of the light, the purer atmosphere and evenness of temperature, the convenience of switching "on" and "off," and the efficient distribution of the light with the absence of glare or shadow are all points which contribute to economical and efficient working. The risk of fire is also less than with any other form of illuminant.

Use of Pulverised Coal.—What is believed to be the first large installation of pulverised coal burning under a complete battery of stationary steam boilers has been in operation since August 1st at the shops of the Missouri, Kansas, and Texas Railroad at Parsons, Kansas. There are eight 250 H.P. O'Brien water tubes, and an evaporation of 10·7 lbs. of water from and at 212 deg. Fah. per pound of fuel was obtained with 16 per cent of carbon dioxide in the stacks. The plant was designed and put down by the Fuller Engineering Company, Allentown, Pa.

Electric Lighting in Mills—Weaving Shed.

## TRADE OF INDIA WITHIN THE EMPIRE.

The Secretary of State for India has authorised the Indian Committee of the Imperial Institute to enquire into and report on the possibilities of further extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire.

The Committee has already commenced its work, and had appointed a number of sub-committees to deal with the more important groups of materials, to consider the results of investigations and enquiries already conducted by the Imperial Institute, and to obtain the views of leading merchants, manufacturers, and other users of the raw products of India.

One of the important aspects of the Committee's work will be to suggest openings for the employment of those Indian materials which before the war went to enemy countries.

The Indian Committee of the Imperial Institute includes Lord Islington (Under-Secretary of State for India), Sir Marshall Reid (member of the India Council), Professor Wyndham Dunstan (Director of the Imperial Institute), Mr. L. J. Kershaw (Secretary, Revenue and Statistical Department, India Office), Sir John Hewett (formerly Lieutenant-Governor of the United Provinces), Mr. George B. Allen (of Messrs. Allen Bros. and Co. and Messrs. Cooper Allen, Cawnpore), Mr. Yusuf Ali (late Indian Civil Service), Sir R. W. Carlyle (lately member of the Viceroy's Council), and Sir J. Dunlop Smith. Mr. C. C. McLeod (Chairman of the London Jute Association) is chairman of the Committee, and the secretary is Mr. A. J. Hedgeland, of the Imperial Institute.

# BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

(*Continued from page 12.*)

HEAT TRANSMISSION.

## Water Circulation in Locomotive Boilers.

Fig. 74 gives a section through a modern locomotive type boiler, and the arrows indicate the direction of the main water currents. The rate of evaporation from the fire-box and first portion of the tubes is very

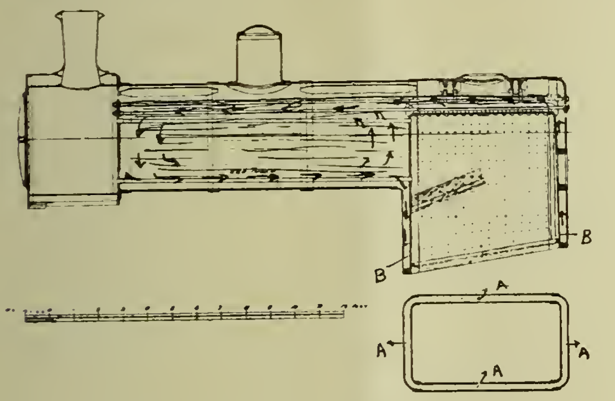



FIG. 74.—BOILER-HOUSE EFFICIENCY.

high, and consequently the "lifting action" of the water takes place at this portion and takes the path shown.

As almost the whole of the fire-box heating surface above the fire level is effective for steam production, it is somewhat surprising that in the narrow spaces A round the fire-box it is possible, with the high rate of evaporation found in locomotive boilers, to provide for the steam being taken away from the surfaces and at the same time ensure that an adequate supply of water takes the place of the released steam on the plate. The motion of the locomotive, however, considerably assists this action

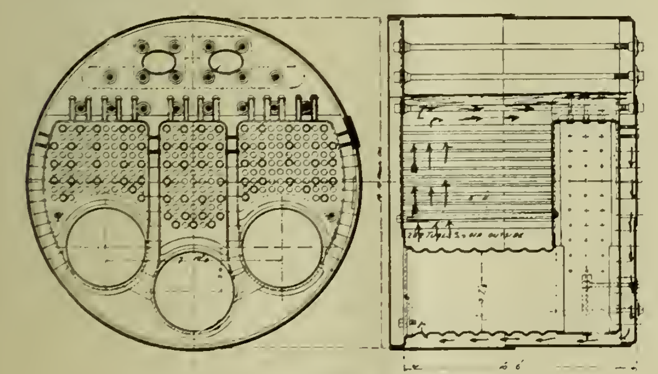


FIG. 75.—BOILER-HOUSE EFFICIENCY.

by causing agitation of the water, which would not otherwise take place.

The restricted area round the fire-box and the change of direction which must take place in the motion of the water at the lower portion B of this area, results in this being the place where deposits of sediment and dirt accumulate, and special doors are fitted to allow for cleaning.

High speed of water movement over the heating surface cannot very well be claimed as a characteristic of this boiler, and the high heat transmission per square foot of heating surface found in locomotive boilers is more due to high furnace temperatures and gas velocities, than to high-water velocity. Taken just from the point of view of providing for good and easy water circulation, the design leaves much to be desired, but its suitability for general use makes this question of secondary importance.

## Water Circulation in Marine Boilers.

The "Scotch" marine boiler shown in Fig. 75 suffers from the same defect as is found in the Lancashire boiler in that the design allows for a large volume of water below the furnace tubes. Circulation of this water is not

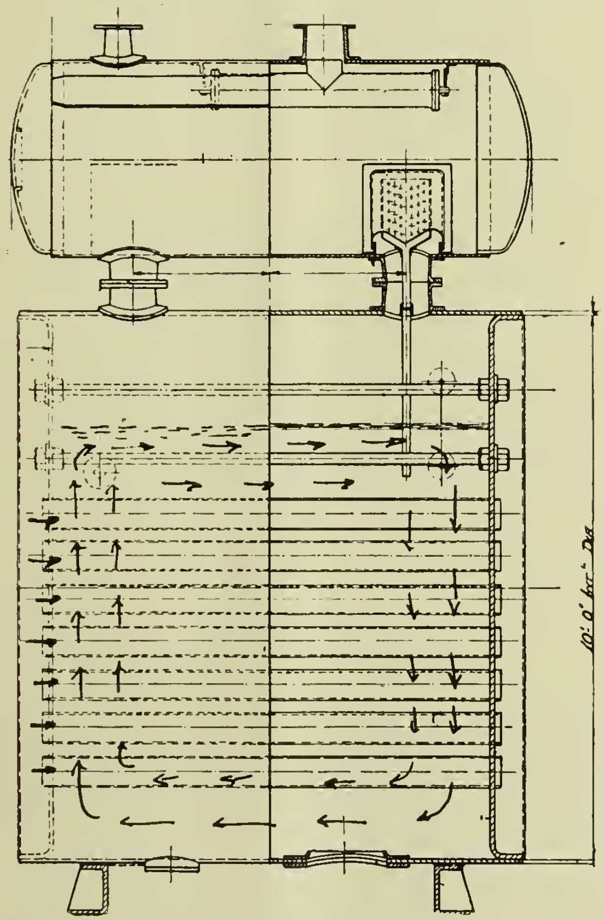


FIG. 76.—BOILER-HOUSE EFFICIENCY.

easy in either type of boiler, and it is a common experience to find the front plate under the furnaces comparatively cool whilst the boiler is doing full duty.

When starting up boilers of this type in order to promote the heat transmission and reduce the straining action on the boilers, marine engineers connect a pump up to the boiler drawing the water from the bottom of the boiler and feeding it back near the water level. In this manner an even temperature throughout the boiler is maintained.

When the use of the pump is discontinued and natural circulation established, the water movements will be somewhat as shown in Fig. 75.

Owing to the manner in which the smoke tubes are packed in the water space, and the comparatively small area between the combustion chambers and the end

plates, easy and free circulation of the water is a difficult matter. The conditions operating amongst the closely-packed tubes must have some similarity to those shown in Fig. 69 (*Industrial Engineer*, Oct. 7th, 1916), but with the added disadvantage that large volumes of steam are rising from the heating surfaces and making it still more difficult to keep the whole of these surfaces wetted.

As in the case of the locomotive boiler, it must be evident that the design of this type of boiler is not such as promotes easy and free water circulation. Other requirements, however, are well met by the design, and experience proves the water circulation possible renders the boiler quite safe and able to give the evaporation demanded in practice.

### Water Circulation in Bonecourt Boiler.

Fig. 76 gives the section through a modern Bonecourt boiler and steam drum. In this boiler the tubes are of fairly large diameter and are spaced so as to give a large water passage between.

About 70 per cent of the evaporation in this boiler takes place over the first third of the length of the tube. When the boiler is evaporating 20 lbs. of water per square foot of heating surface, the average evaporation in the first third of each tube is 42 lbs. of water per square foot.

Consequently, the convection currents set up are exceedingly strong, and the path taken by the water will be as indicated in the diagram. The main resistance offered to this water movement will be by the tubes. There are, however, no contracted spaces as in the other types considered.

Further, the rate of heating will be fairly even in all the tubes, and as these are evenly divided over the "water-section" of the boiler, it follows that the convection currents set up will be very even in intensity over the whole boiler.

These influences combined will promote good circulation and will account for the automatic shedding of the scale from the heating surfaces which is found with this boiler.

The steam, as it is generated, gets away quickly, and there is no obstacle in the way of the water quickly replacing the steam on the heating surfaces. Consequently, there is little risk of burning the tubes or of producing wet steam when boilers are forced.

*(To be continued.)*

## THERMALENE A SUBSTITUTE FOR ACETYLENE.

The thermalene gas of Mr. K. F. Wolf, of Zurich, Switzerland, which is recommended as a substitute for acetylene, especially for welding, is described as an acetylene, which, in its generation, is impregnated with oil gas and thereby rendered less explosive than acetylene and more suitable for lighting. Thermalene is generated in closed tin cases or cartridges which are charged with alternating layers of calcium carbide and of sawdust; the latter is soaked in oil; the kind of oil used is not specified in the "American Machinist" of September 2nd, 1916, from which we quote. When water penetrates into a cartridge from below—the cartridge having been pushed into the generator—acetylene is liberated with the evolution of heat, the oil is heated, and the acetylene becomes impregnated with oil gas as it forces its way through the sawdust. As the resulting lime expands considerably, and as the oil and carbide must not come in direct contact with one another, the layers of carbide and of oil are separated by two discs of cardboard, between which spacers (metal spirals) are interposed. The lime and impurities in the carbide remain in the cartridge and are ejected with it; it is also claimed that the carbide in a cartridge need not all be decomposed at the same time. The cartridges, 8 in. high, 4⅜ in. diameter, weigh 6 lb. each. The largest cartridges weigh 40 lbs. The resulting thermalene gas is described as heavier than air, density 1·1, and as less eplosive than acetylene; liquefied thermalene is not explosive at all. The gas requires less oxygen than acetylene for burning, and its specific heat is only one-eighth of that of acetylene; mixing better with oxygen, it is said to give a better flame and not to absorb carbon from the iron in welding, so that a soft weld is obtained, especially with cast iron. Thermalene is also credited with having a sweet, not unpleasant smell, and with not being poisonous. A portable welding outfit consists of generator, gas storage tank, and oxygen cylinder. The weld is made with the aid of a torch, which is specially designed against flashing back. The thermalene pipe and the oxygen pipe are screwed into the mixing chamber or body of the torch, which is provided with thermal screens; the thermalene passes directly into the chamber, the oxygen enters a nozzle, which goes through the chamber and screens and terminates at the far end of the chamber, there it narrows into the long torch nozzle. Should the flame flash back, therefore, it would not burn in the chamber, which otherwise might be fused. Special tips to be screwed to the torch are provided with the nozzle in 12 sizes.

## OIL ENGINES IN HONG KONG.

In spite of the general depression of trade noticeable in all lines, and especially in those lines of trade which depend directly upon Chinese consumption, there seems to be a continued demand in China for internal-combustion engines of several varieties, and especially for marine motors. The growth of the trade in normal years has been remarked upn by nearly all trade authorities, the Commissioner of Customs at Canton, in his recently published annual report, saying, for example:—

"The demand that is becoming noticeable for oil engines, both stationary and marine, is due chiefly to recent improvements in motors permitting the use of crude oil in place of the more expensive petrol, and a large development of this trade in the near future may confidently be predicted. Crude-oil motors for irrigation purposes were erected during the year in the Ko Ming district on the West River, near Samshui, and larger engines of similar type were also imported for the use of the Fatshan Electric Supply Co. Oil engines, usually an exact copy of some foreign pattern, are being made locally by the Chinese engineering firms, who are presumablf alive to the growing demand for motive power in a handy form."

From a recent report by the United States Consul-General in Hong Kong, it appears that the manufacture of such motors in Canton, or elsewhere in China, so far has not developed to any considerable extent, nor is it likely to do so for some time to come so long as prices of imported motors are reasonably low. The use of motor pumps for irrigation along the West River has not been very successful, though the outbreak of the war in Europe and the collapse of South China's foreign trade have prevented a fair test of the demand for engines for such purposes.

The war has also directly affected the development of the motor-boat traffic on South China rivers by causing the depression which has existed for months in all lines of Chinese activity. Nevertheless, the trade has continued in fair volume, and with the advent of normal conditions in this field the demand will increase greatly. The type mostly in demand is a simple motor with few working parts and an ability to stand exposure, dirt, and neglect, and using crude oil or petroleum as fuel. The demand is mostly for marine motors and motors suitable for small electric light and power plants, and for running very small industrial establishments.

## WELDED REPAIRS.

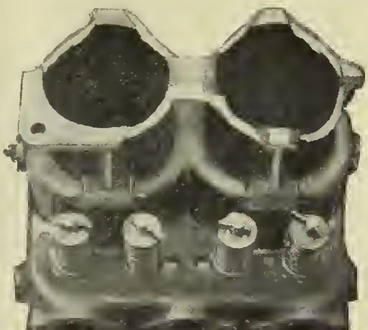
The inestimable advantages conferred upon the engineering industry by acetylene and electric welding are more apparent every day, and have been recently emphasised to us by a visit to Messrs. Barimar's Repair Works. The activities of this firm in war-time give a good idea of the business transacted by this company. So great has been the demand for its services that a new and commodious factory, illustrations of which are given herewith, in Lamb's Conduit Street, London, has been acquired. Here armies of Barimar specialists in welding, general motor engineering, and sheet-metal work are busily engaged day and night. A great proportion of the company's work is done in connection with naval, military, and munition orders, while in the motor world it is daily becoming indispensable, so that in these days Barimar's business has become one of national importance.

There are departments specially equipped for the repair of cracked and broken cylinders, crank cases, gear boxes, differential cases, shafts, etc.; in another machine-room gears are cut, cylinders re-ground, pistons machined, connecting rods made, and twisted crank shafts straightened and re-ground.

On another floor are from 200 to 250 lorry, aeroplane, and motor-car radiators, and hundreds of damaged lamps, all awaiting treatment. New radiators of every type for lorries, motor cars and cycle cars, and light-weight radiators for aerial work are manufactured. Other sections of the works are specially equipped for the quick and economical repair of magnetos and accumulators, each department being in charge of a specialist.


Barimar Headquarters, 10, Poland Street, W.


A View of Barimar Works.



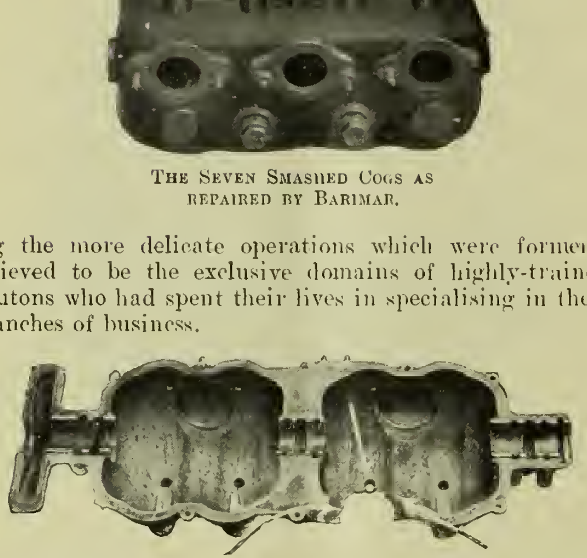
A Set of Cylinders with Several Smashed Cogs.

Since Barimar repaired these Cylinders they have been in daily use for over two years, and have never shown signs of weakness.

During the past few months Barimar Ltd. has sprung into notice in quite a new branch of business activity. While the new Government Committee has been engaged

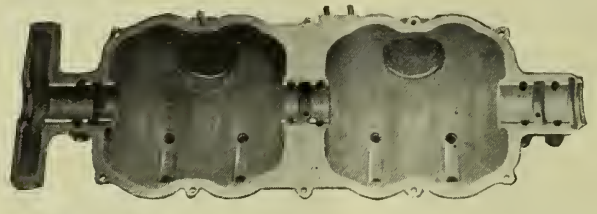
in important work in connection with scientific and industrial research, with the view of rendering this country independent of alien manufacturers, Barimar specialists have on their own initiative stepped into the front rank of scientific welders, and are daily performing the more delicate operations which were formerly believed to be the exclusive domains of highly-trained Teutons who had spent their lives in specialising in these branches of business.

The Seven Smashed Cogs as repaired by Barimar.



This Aluminium Crank Case was not only repaired by Barimar, but was restored. A whole new section of matter has to be cast and welded in, and when machined and finished the crank case was as new.

After an interesting visit to these works, which are the scene of intense activity, one saw visible proofs in photographs of large numbers of operations successfully performed by Barimar specialists, and scores of letters from satisfied customers (including some of Britain's leading engineers), convincing and conclusive evidence that Barimar is at the head of a great and growing national industry.



Aluminium Crank Case as completed by Barimar.

## INSTITUTION OF MECHANICAL ENGINEERS: PRESIDENTIAL ADDRESS.

By W. Cawthorne Unwin, LL.D., F.R.S.

It has not been usual for the President to make a formal address at the opening of the session in his second year of office. I do not know whether this is due to consideration for the President or is a measure of relief to members. In normal times I should not have departed from precedent. But with your acquiescence I should like to make a short statement, partly to explain the position of the institution, partly to expand a point in my address a year ago. I recognise that a statement by the President is not discussed, and that his views, if erroneous, do not commit the institution. He is the more bound to be careful and moderate.

### Restricted Activities of the Institution.

The conditions of the time have unavoidably restricted some of the activities of the institution. We have placed our building at the disposal of the Government, and there is no immediate prospect of regaining the use of it. Happily, through the kindness of the Institution of Civil Engineers, who permit to us the use of their meeting hall and library, the inconvenience of our members has been much diminished. It is a difficulty that six members of the office staff of the institution have been called up for active service, and it is inconvenient to the secretary to carry on the considerable business of the office with untrained assistants. Nevertheless, so far the meetings have been held regularly; several provincial meetings have been held, and the Journal has been issued as usual. The Council decided that it was impracticable to hold the summer meeting, the conversazione, or the annual dinner when so many members were absorbed in war work. In this they have taken the same course as other scientific societies.

### Candidates for Election.

The number of candidates for election does not seem to have been much affected by the war. Taking the first six months of the year, the number elected was 129 in 1914, 100 in 1915, and 112 this year. As would be expected, somewhat fewer candidates have presented themselves for examination. Nearly 900 members of the institution are known to be on active service, and many others are engaged on munition or other war work. Unhappily, so far as is known, 29 have died on service and 30 or probably more have been wounded. Our sincere sympathy goes out to their friends in their bereavement. They had died in a great cause and in the service of the country in its extreme need. So far as we know, 15 members on active service have been decorated and eight mentioned in dispatches.

It would not be right to pass over, without an expression of our deep sorrow, the deaths of Sir H. Frederick Donaldson, K.C.B., a past-president, and of Mr. Leslie S. Robertson, so long the secretary of the Engineering Standards Committee. They were lost in the disaster to H.M.S. "Hampshire," when accompanying Lord Kitchener on a mission to Russia.

There had been rather more difficulty than usual in obtaining papers for the present session, but I trust we may have no mishap. We have tried to obtain a paper dealing with the work of women in munition factories, but so far have not succeeded. It is believed that their services have been invaluable, and that for such work as they can undertake they are little inferior to male workers, either as regards quantity or quality. We hope to have one or more papers on the special machinery for shell manufacture; also shortly a report from the Hardness Tests Research Committee.

### German Progress should be Considered.

In my address a year ago I urged that the rapid economic progress of Germany since the war of 1870, and chiefly in the last 25 years, should be very carefully con-

sidered. Relatively, Germany has progressed in many industries much faster than we have. If we are to recover our position, as I believe we may do in the new conditions after the war, it is necessary we should study accurately the facts and causes of German expansion. No doubt that expansion has been too rapid to be healthy, and seems to have induced a feverish sense of insecurity, so that under whatever inspiration the war began, it is certain that commercial and industrial necessities and ambitions had a large place. As an example, which appeared to me remarkable, though it is only one of several, I referred to the iron and steel industry, in which not so long ago we were supreme, but in which we now hold third place, and not a good one at that.

### Pig Iron in Germany.

In a quarter of a century the production of pig iron in Germany has trebled and that of steel has sextupled. In 1913 Germany produced 18 million tons of steel, and we produced 7 million tons. It is quite true that nations must depend on each other for products which each is best able to manufacture, but this hardly applies to the iron and steel industry. We have not been wanting in metallurgical knowledge nor obviously worse off in natural resources. Hence the rapid increase and present magnitude of the German production of iron and steel seems to me to have a lesson for us. German trade is conducted thoroughly and unscrupulously as a warfare, and it may well be that the fostering of the iron and steel industry is to be reckoned amongst the preparations for war, for without a great capacity for iron and steel production the present war could not be prosecuted. It is impossible to ignore the ambition frankly stated by Dr. Ostwald, the distinguished Leipzig professor, that Germany, "having become the military centre of Europe, it was necessary for her to become the industrial centre also."

### "We are always Grumbling at Ourselves."

In a very interesting address to the Royal Society of Arts, Dr. Dugald Clerk made a protest against the tendency to contrast unfavourably British achievements in science and industry compared with those of Germany. With most of this address I heartily agree, and in any case I should differ from Dr Dugald Clerk with reluctance and even with some trepidation. Many years ago Walter Bagehot wrote, "We English are always grumbling at ourselves. But, after all, England is a success in the world; her career has had many faults, but it has been a fine and winning career on the whole."

Dr. Dugald Clerk quoted my reference to the iron and steel industry, and replied to it that "it is misleading to cite the relative production of iron and steel as proving either the prosperity of Germany or the decadence of England." As an explanation of the difference in this matter of England and Germany, Dr. Dugald Clerk says that "the United Kingdom has a total of 23,000 miles of railway and Germany has 38,000 miles," and that "it would be extraordinary if a capable and industrious nation, such as the Germans are, could not succeed in making most of the steel required for their own use." But he had forgotten that in India there are 33,000 miles of railway, almost as many as in Germany, mainly built and maintained by the use of English steel, and railways in other Colonies naturally supplied from this country. The railway mileage test does not seem to explain the large German production of steel.

*(To be continued).*

## "SPEEDING-DOWN" STEAM ENGINES.

By Edward Ingham, A.M.I.Mech.E.

The title of this article may sound strange to most readers, because one seldom hears of an engine being "speeded down." To speed up an engine is, of course, a somewhat common procedure, and is generally done with the object of obtaining more power from the engine. To speed down will obviously mean reducing the power of the engine, and it is rather strange that in certain cases this procedure is often not thought of, since it might result in considerable economy.

It is generally recognised that when an engine is overloaded, or in other words, when it is too small for its work, and when in consequence the steam is released at a comparatively high pressure, owing to the fact that admission takes place for a considerable portion of the stroke, great benefit may be derived by increasing the speed of the engine. By so doing the steam may be cut off earlier and greater gain obtained from expansive working. Just as speeding up a heavily-loaded engine results in greater economy, so in the case of a lightly-loaded engine much benefit might be obtained by reducing the speed of running.

### Every Engine has a Most Economical Load.

Every engine driving a load which is practically constant, as at cotton mills and textile factories generally, has a most economical load, viz., the load for which it was designed. If the engine be worked with either a greater or a less load than this, wastage of steam and consequently increased fuel consumption will be the result. Now a lightly-loaded engine is always much more wasteful than a heavily-loaded engine. In most cases the chances are that an engine will be over rather than under-loaded, because in general a steam user increases the number of his machines rather than reduces them as time goes on. Still, it is no uncommon thing to come across a lightly-loaded engine, because many steam users, with a view to future extensions, purposely instal an engine with some margin of power. This is, of course, a wise provision, but the danger is that the steam user, having little idea as to what the actual power should be, will purchase an engine very much too large for its work. Too often he is wrongly advised in regard to this.

### Gains by Reducing Speed.

Now it has to be remembered that when an unduly large engine is purchased not only is the cost of running very high, owing to the large quantity of steam used by the engine, but the first cost is excessive. As regards the latter nothing can be done, but so far as the cost of running is concerned a great deal can be done by reducing the speed of running. The general effect of reducing the speed of an engine is to give a larger indicator diagram. That this is so should be obvious, because since the same work has to be performed at a reduced speed, the area of the work diagram must be increased sufficiently to compensate for the reduction in speed.

### The Case of a Variable Expansion Engine.

In the case of a variable expansion engine, the valves will not cut off the steam until a later point of the stroke is reached, so that the engine can develop the necessary power at the reduced speed. Previously, the engine would be running with a very early cut-off, and it is due to this fact that the engine would be so wasteful in steam. When cut-off takes place very early, the temperature variation of the cylinder walls during the cycle is considerable, and this means that a large quantity of steam is condensed in the cylinders. Thus, when the steam first enters the cylinder,

it comes into contact with the metal surfaces of the cylinder, which surfaces have become cooled down by contact with the low-pressure exhaust steam of the previous stroke. A transference of heat then takes place between the steam and the metal walls, with the result that an excessive quantity of steam condenses, and the bulk of this condensed steam, although it is evaporated later in the stroke, does little useful work in the cylinder.

### The Question of Cut-off.

By cutting off later the temperature variation of the cylinder walls is reduced, and consequently so also is the condensation loss. It has also to be remembered that with a very early cut-off the steam pressure, owing to the large rates of expansion, will often fall below the back pressure, a negative loop being formed on the indicator diagram. This again means serious loss, since the piston, instead of rotating the crank, has to be dragged along by the crank during the latter portion of the stroke. In the case of a throttling engine the point of cut-off is a fixture, and the indicator diagram, when the engine is under-loaded, will show the steam admission line to be throttled down to a pressure far below the boiler pressure. By reducing the speed of the engine the steam line is raised and a larger and better diagram thus obtained, the negative loop being removed.

In one sense a reduction of speed will tend to increase the loss from condensation, because it allows more time for heat exchanges to take place between the cylinder walls and the steam; in other words, there is more time for the walls to fall to the temperature of the exhaust steam during the latter part of the stroke. The increased loss from this cause is, however, scarcely appreciable, and will be far more than outweighed by the economy resulting from the later cut-off and consequently reduced condensation.

### Mechanical Efficiency of Lightly-loaded Engine Low.

Apart from being very wasteful in steam, a lightly-loaded engine has usually a very low mechanical efficiency. In other words, the power expended in overcoming friction of the various parts of the engine is usually a large proportion of the total power developed by the engine. It is not generally realised that the friction of an engine is practically constant at all loads. The indicator diagram from an engine driving no load is an attenuated one, and represents, of course, the work required to drive the engine itself against its own friction. Many years ago Dr. Thurston made experiments which proved that under usual conditions of working and at all ordinary speeds and steam pressures the diagram taken from the engine with no load on may be safely taken as a measure also of the friction at full load.

### Reducing Speed means Other Alterations.

To reduce the speed of the engine will obviously necessitate certain alterations. The machines driven by the engine are generally designed to run at a constant speed, which cannot, as a rule, be altered. Hence, either the main driving pulley will have to be substituted by a larger one, or else the driven pulleys will require substituting by smallar ones. In cases where there are a number of driven pulleys, each driving a certain section of the machinery, and driven direct from the main engine pulley, it would probably be cheaper to substitute the main pulley than to substitute all the driven pulleys.

Whichever method be adopted, the lengths of the driving belts or ropes will, of course, require altering. If the main driving pulley be substituted by a larger one, the ropes will have to be lengthened, whilst if the driven pulleys be substituted by smaller ones the ropes will require shortening.

Alterations will also be required to the governor gear. The governor and its mechanism are designed for a certain speed, and this speed must remain the same, no matter how the engine speed be altered. Consequently, either the ratio of the gearing must be altered or else the weight of the counterpoise, which must be reduced.

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

## GERMANY AND WORLD'S TRADE.

*To the Editor of "The Industrial Engineer."*

Sir,—Germany's intention to obtain an initial advantage in the fight for the world's trade is plainly seen in the social and economic reconstruction that has been proceeding throughout the Fatherland side by side with the country's gigantic efforts on all the war fronts. In nothing is this idea of Germany more plainly seen than in the latest scheme announced, by which the great armouring firm of Krupp, with its scores of thousands of mechanics, is to be linked up with the North German Lloyd Steamship lines. The Essen firm has now purchased an interest in the steamship company, and one of its directors is to have a seat on the Board.

When war broke out official Germany had so organised its machine shops that only the pressure of a button was required to switch all the works on to munition making. All that is happening now shows that at the psychological moment the same procedure will be adopted, with this difference—German machinery will make wares for the world's marts instead of munitions for the Fatherland.

The adroit move of Krupp and the steamship company is not a mere private commercial transaction. It has a much wider significance, of which we in this country should take due note. While Teuton submarines have been busily engaged sending to the bottom as many British ships as possible, existing German craft have been safely interned in home or neutral ports. Meanwhile, German shipbuilders have been steadily building new vessels for the mercantile marine, some of them of 20,000 tonnage.

It is Germany's ambition to emerge from the war, even if beaten, as the first shipping power in the world, and the new link forged between Essen works and Bremen ships is another move in a well-matured plan to realise this aim.

The question naturally arises in one's mind whether we, as a nation, shall once more be caught napping. The British Government has had to be whipped into action in many directions, and even to-day it seems next to impossible to close up German businesses in Britain long since marked down for extinction. How far positive progress has been made by any of the Government Committees appointed to consider questions of after-the-war trade it is impossible to say, since not one of the Committees has issued a report. Months ago there was noticeable activity in certain industries, chiefly in the formation of trade associations, but this seems to have died down.

Wise men judge the future by the past, and, adopting this formula, we shall probably find that British trades and industries will progress and flourish just in proportion as they concentrate their energies now upon perfecting their organisations and co-operating in a commercial campaign conducted in every corner of the world. In a word, our industries will rise or fall according to the wisdom and the extent of the efforts of their organisers.

So far as the motor engineering industry is concerned, we feel that it will require a far more powerful effort than has yet been put forth if it is to cut a creditable figure in the impending trade war, and anything that the Government can do to strengthen the position will be heartily welcomed.—Yours truly,

Barimar Limited (Scientific Welding Engineers),
C. W. Brett,
Managing Director and General Manager.

## Trade Items, Notes, &c.

Gas Producers.—In Italy and Germany gas producers fed with peat and provided with ammonia-recovery plant are stated to be in successful operation for the generation of electricity.

A Wire-wound Pipe.—A 6,500 ft. continuous wire-wound wood stave pipe, 10 in. in diameter has been constructed in California. The complete line pipe is covered with asphalt and buried in a trench.

"Some" Searchlight.—The General Electric Company, of Schenectady, N.Y., has lately completed for the U.S. Navy a searchlight with a 5 ft. mirror, the rays of light from which can, it is claimed, be seen at a distance of 200 miles.

U.S.A. Railways.—The United States not only leads all other nations in the world in possessing 257,569 miles of railways, but exceeds Europe's mileage by 50,000 miles. The equipment of the United States railways includes 65,000 locomotives and 2,327,000 cars. The average number of employees is 1,409,342.

French Helmets.—Over 3,500,000 helmets have now been made for the French Army. They are stamped out of the best sheet steel. Each helmet is made up of four pieces—the cap, the peak, the neck protector, and the crest, and they are riveted together and sprayed with a grey-blue paint, just sufficient to prevent rust. A helmet requires about 2 lb. of steel and a little aluminium to stiffen the lining.

Alloy for Valves.—An alloy for the valves of internal-combustion engines, invented by W. E. Oakley (U.S. Patent 1,175,172, March 14th, 1916), has the following average composition: Copper, 30 per cent; nickel, 67 per cent; iron, 3 per cent. This alloy, it is claimed, has approximately the same coefficient of expansion as the cast iron of the engine cylinders, and is but slightly affected by the highly heated gases.

Strength of Cast Iron.—The strength of cast iron is increased by the addition of wrought iron added during the melting process, the increase being approximately as follows: With 100 parts of cast iron, 10 parts of wrought iron increases the strength 2 per cent; 20 parts of wrought iron increases the strength 32 per cent; 30 parts of wrought iron increases the strength 60 per cent; 40 parts of wrought iron increases the strength but 33 per cent. The maximum result is therefore produced with 30 per cent wrought scrap.

Gas Coke Instead of Coal.—The Deptford Borough Council has recently carried out experiments in the use of gas coke instead of coal as a fuel for boiler furnaces. A trial extending over four weeks was made with forced draught, as recommended by the London Coke Committe, from which the following results were obtained: The total coke consumed in the four weeks was 81 tons 19 cwts., at a cost of £110 19s. 6d. The price of the coke was 27s. 1d. per ton, against 39s. 6d. per ton for the best steam coal usually consumed. The average quantity of coal consumed in the corresponding period for the three previous years was 67 tons, at a cost of £132 6s. 6d. This shows a saving, by burning coke, of £21 7s., or £5 6s. 9d. per week. The cost of the forced-draught apparatus was £12 12s.

U.S. Marine Engineers.—A new law is in contemplation in the United States of America which requires every ocean and coastwise sea-going merchant vessel of 1,000 gross tons and over, propelled by machinery, to carry three licensed assistant engineers, and one licensed chief engineer, irrespective of size of engines, quantity of machinery on board, or importance of engineering work to be performed. The same type of vessel of over 200 gross tons and less than 1,000 engaged in similar service, and a vessel of from 100 to 200 gross tons engaged in trade at sea on routes of more than 24 hours, must have on board three licensed engineers.

Boiler Firemen.—The practice of putting steam boilers into the hands of non-technically instructed people, either for instalation repair, or usage is most reprehensible, as the risk incurred is great. It is not necessary for a boiler attendant to be an adept scientist or an engineer, or even a boilermaker, as none of these is at all likely to have received any special training in this direction. The man to select as a boiler attendant or engineman should be sensible, steady, methodical, and inquisitive. He should have the qualities of a man who has a respectful fear of a gun whether loaded or unloaded—a careful intelligent person, with sufficient commonsense to act according to the instructions of those in charge of the plant, presuming, of course, that they are technically trained engineers.

Harnessing the Tides.—A proposal recently made to harness the tides of the Bay of Fundy, at Cape Split, Nova Scotia, by means of a current motor, which would pump the water into huge reservoirs on the cliff above the descending water furnishing the power, has been followed by a suggestion to utilise the Reversing Falls at St. John, New Brunswick, in a like manner. The suggestion has come from the acting resident engineer of the Department of Public Works, who says that a stronger current is available at the falls than at Cape Split, and there would be a longer period between tides for a motor pump to operate.

Vibration in Turbo-generators.—An article in a French engineering journal describes a case of vibration which occurred in Russia with a turbo-generator. It ran perfectly until the exciting current was switched on; then the whole building began to shake, and the machine had to be stopped. Careful examination showed that there was no defect in the machinery itself, and the vibration was then discovered to be due to resonance. The effect was caused by the box girders to which the machine was bolted; as soon as the front bolts were slightly loosened the vibration ceased. A permanent remedy was found in the employment of the Pearson type of coupling wherein thin sheets of copper are inserted between the surfaces, which are bolted together.

Cast Iron Containing Steel.—According to a French technical journal the manufacture of cast iron containing steel is most easy and can be carried out even in small foundries. The manufacture has largely increased in France since the war began. Whilst two years ago very few foundries would have undertaken the supply of a metal showing a tensile strength of 25 kilogs. per square millimetre (15·87 tons per square inch), at the present time the average of 30 kilogs. per square millimetre (19·05 tons per square inch) is very frequently met, together with a number of stringent shock tests. The metal obtained is an ideal one for the rapid and safe manufacture of shells.

Japanese Shipowners and the War.—Japanese shipowners, shipbuilders, and merchants are reaping a full harvest from the war, and securing markets into which, but for the present opportunity, they might never have been able to find a way. For instance, prior to the war the shipbulding trade of Japan was confined to orders from a few of the larger shipping companies. To-day many British builders can neither accept orders from foreigners nor from British owners, with the result that Japanese builders have seized the chance, and are turning out boats in great and growing quantities for Japanese owners, a few of whom are offering them for sale on this side at such prices that only neutral owners can consider them.

Clinker from Refuse.—In Wolverhampton clinker from the refuse destructor is being used for the construction of road surfaces. The clinker, taken direct from the destructor, is crushed in a mortar-grinding mill and passed through a screen, the finer portions being used for the carpet or top coat and the coarser for the bottom or binding course. It is then conveyed to open-hearth driers, heated to the necessary temperature, and elevated to the mixer, whence, after the necessary quantity of mexphalte (bitumen) has been incorporated it is carted to the road, which is prepared for its reception by scarifying the existing surface and removing it to the required depth. The bottom course is then laid to a depth of about 2 in. and rolled, and after it has cooled the carpet coat about 1 in. thick is spread and also consolidated by rolling.

Idle Machinery.—The Minister of Munitions has set up a Central Clearing-house Organisation for tracing and registering machinery which is idle or about to become idle. The organisation will endeavour to ensure that contracts placed by the Ministry are directed towards any unoccupied manufacturing capacity which may exist in the country. It is also desired to place engineering contractors who have suitable facilities for particular supplies in touch with the Ministry and with other Government departments requiring these supplies, and to help contractors who are able to undertake additional or more suitable work now or at a future date to maintain continuous employment of their machinery and labour. Manufacturers possessing idle resources and desiring to be placed in touch with Government contracting departments are invited to communicate with the Central Clearing-house, Ministry of Munitions, Northumberland Street, London, S.W.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS.

### October 2nd to October 21st (inclusive).

Austin Motor Co.: Supply of fuel to cylinders. 14,214.
Anderson, J.: Electric motor controllers, &c. 15,007.
Becht, L. A.: Valve mechanism. 14,414.
Benn, J. B.: Taps or cocks. 14,596.
Berriman, A. E.: Shut-off cocks. 14,392.
Berriman, A. E.: Carburettors. 14,403.
Blanchard, C.: Coal, &c., cutting-machines. 14,349.
Bland, J. J.: Pumps. 14,561.
Breckwoldt, S. M.: Single-acting power-transmission device. 14,464.
Breckwoldt, S. M.: Double-acting power-transmission device. 14,465.
British Thomson-Houston Co.: Centrifugal compressors. 14,335.
British Thomson-Houston Co.: Electric ship propulsion. 14,518.
Brophy, M. M.: Mechanical movement. 14,637.
Brown, W. F.: Shut-off cocks. 14,392.
Brunner, G. E. de: Force pumps. 14,575.
Burridge, A.: Chain link for driving-chains, &c. 14,365.
Bussell, R. C.: Vapour burners. 14,404.
Bibby, H.: Belts, conveyers, &c. 14,077.
Bignami, J. B.: High-tension magneto machines. 14,218.
Boulard, H.: Method of working boilers. 14,102.
Braithwaite, H. A.: Stay-bolt heads in locomotive fire-boxes, &c. 13,998.
Bailey, A. J. & F. M.: Fluid-pressure testing-apparatus. 14,921.
Beardmore, Sir W.: Securing sparking-plugs. 14,827.
Belyavin, P.: Starting internal-combustion engines. 14,837.
Binche, G.: Two-stroke-cycle explosion motors. 14,811.
Blanch, H. J.: Sparking-plugs. 14,660.
Brace, H. M.: Internal-combustion engines. 14,954.
British Thomson-Houston Co.: Vacuum pumps. 14,821.
Brookes, A. J. C.: Aerial ropeways. 14,893.
Brown, E. O.: Pumping-machinery. 14,846.
Brundrit, J.: Feed-water heaters. 14,697.
Bullivants' Aerial Ropeways Ltd.: Rope runways. 14,898.
Clark, W. W.: Acetylene generators. 14,808.
Cox, A.: Appliances for use with engines to adapt same for paraffin. 14,847.
Crane, A. E.: Radiators and condensers. 14,972.
Chitty, H.: Electric machines. 14,345.
Clerget, P.: Engine, &c., connecting-rods. 14,538.
Crowley, J. F.: Tension devices for driving-belts. 14,400.
Chillington Tool Co.: Gas and air injector apparatus. 14,192.
Chillington Tool Co.: Gas furnaces. 14,193.
Coatalen, L.: Oil-filters for internal-combustion engines. 14,143.
Cochrane, W.: Internal-combustion engines. 14,281.
Collins, P.: Vaporisers for engines. 14,051.
Conklin, B.: Rotary engines. 14,047.
Constantinesco, G.: Alternating fluid-current motors. 14,035.
Constantinesco, G.: Transmitting pressure between fluid columns and moving surfaces. 14,036.
Constantinesco, G.: Alternating fluid current motors. 14,037.
Constantinesco, G.: High-frequency fluid-wave transmission generator. 14,039.
Daimler Co.: Shut-off cocks. 14,392.
Daimler Co.: Carburettors. 14,403.
Dodson, E.: Pumps. 14,477.
Donald, D.: Valve mechanism. 14,378.
Donald, L. M.: Valve mechanism. 14,378.
Dunlop, P.: Centrifugal pumps. 14,486.
Durnford, C. W.: Electric motors. 14,417, 14,423.
Durnford, C. W.: Combined pumps and electric motors. 14,422.
Daw, W. H.: Carburetting air. 13,948.
Detroit Motor Appliance Co.: Temperature-controllers for internal-combustion engines. 14,253.
Dickson, A. S.: Testing coal. 14,126.
Dale, W. B.: Fluid-pressure testing-apparatus. 14,921.
Dansk Jernbetonkonstruktions Co. Danalith Aktieselskab: Distributing-arrangement for water-cooling towers. 14,901.
Dick, T. H.: Emergency safety valves. 14,980.
Dolgolenko, V.: Means for atomising liquid fuel. 14,759.
Dugon, A. L.: Recording-gauges, indicators, &c. 14,870.
Ellacott, E.: Belt conveyers. 14,120.
Ellison, G.: Electric motor controllers, &c. 15,007.
Forchhammer, O.: Single-acting power-transmission device. 14,464.
Forchhammer, O.: Double-acting power-transmission device. 14,465.
Frayn, A.: Starting of internal-combustion engines. 14,625.
Fell, G. N.: Ignition systems of internal-combustion engines. 14,218.
France, A.: Apparatus for washing coal, &c. 14,099.
Farley, J.: Smoke-consuming furnaces and water-heaters. 14,680.
Favero, M.: Sparking-plugs. 14,660.
Ferranti, S. Z. de: Electric welding. 14,699.
Fiddyment, J. C.: Power presses. 14,683.
Foster, H. K.: Protecting water-cooled engines, &c., from effects of frost. 14,783.
General Electric Co.: Centrifugal compressors. 14,335.
General Electric Co.: Electric ship propulsion. 14,518.
Giles, G.: Electric condensers. 14,416.
Gorely, C.: Prime movers. 14,432.
Goss, A. A.: Rail-joints for railways. 14,431.
Giblett, P. H.: Internal-combustion engines. 14,299.
Guinness, K. E. L.: Ignition apparatus for engines. 14,246, 14,247.
Garland, W. G. de F.: Reversible propeller. 14,803.
General Electric Co.: Vacuum pumps. 14,821.
Gorely, C.: Steam-raisers. 14,712.
Grace, C. J.: Carburetting air. 14,917.
Grant, R. E.: Acetylene generators. 14,808.
Green, F. W.: Fuel-economisers. 14,956.
Hall, A.: Valves, cocks, &c. 14,577.
Hallimond, A. F.: Electro-magnetic separator. 14,629.
Hayes, E. W.: Liquid-fuel vaporiser. 14,385.
Habets, P.: Apparatus for washing coal, &c. 14,099.
Hammond, E. V.: Internal-combustion engines. 14,130.
Harrisson, C. S.: Non-sooting sparking-plug. 14,262.
Heyl, G. E.: Liquid fuels for firing furnaces. 14,148.
Hult, C. A.: Ignition apparatus for explosion motors. 13,984.
Hult, O. W.: Ignition apparatus for explosion motors. 13,984.
Husebye, J. A.: Repairing electric power-transmission lines. 14,068.
Hutchinson, E.: Carburettors. 14,009, 14,010.
Havercroft, A. E.: Smoke-condenser. 14,815.
Hellewell, G. T.: Stop-motions for looms. 14,907.
Howden & Co., J.: Steam-generators. 14,994.
Howden & Co., J.: Steam-generators fitted with superheaters. 14,995.
Howden & Co., J.: Feed-water heating and distributing devices. 14,996.
Humber Ltd.: Radiators and condensers. 14,972.
Hume, J. H.: Steam-generators. 14,994.
Hume, J. H.: Steam-generators fitted with superheaters. 14,995.
Hume, J. H.: Feed-water heating and distributing devices. 14,996.
Hutsell, T. A.: Internal-combustion engines. 14,686.
Ireland, H. W. F.: Sparking-plugs. 14,807.
Johnson, A.: Coal, &c., conveyers. 14,487.
Jones, L. T.: Clutch and gearing-arrangement for motor-cars. 14,493.
Jenkins, H. C.: Belt conveyers. 14,120.
Johnson, G.: Compressed-air engines. 14,014.
Jones, A. T. Salisbury-: Carburettors. 13,983.
James, C.: Piston-rings. 14,689.
Joseph, S.: Lubrication of valves. 14,762.
Jullin, A. J.: Voltage or intensity regulators. 14,825.
Jullin, A. J.: Regulating voltage of dynamos. 15,008.
Jullin, A. J.: Regulating voltage of dynamos. 15,009.
Jullin, A. J.: Regulating voltage of dynamos. 15,010.
Kuhl, P. C.: Gas turbines. 14,512.
Keppie, P. R.: Speed indicating and control mechanism for marine, &c., engines. 14,076.
Kinchin, J. W.: Supply of fuel to cylinders of engines. 14,214.
Kirke, P. St. G.: Superheaters. 14,086.
Kay, J. H.: Coal-gas-making apparatus. 14,857.
Keeley, T. R.: Centrifugal blowers or fans. 14,875.
Knyff, R. de: Pressure-reducers. 14,738.
Lanchester, F. W.: Fuel-feed valves. 14,301.
Lang, C. R.: Duplex pumps. 14,131.
Lang, C. R.: Steam-jet air-ejectors. 14,132.
Lang, C. R.: Steam-jet air-ejectors. 14,258.
Leech, W. S.: Pulleys and wheels. 14,001.
London General Omnibus Co.: Heavy-fuel carburettors. 14,173.
Lanchester, F. W.: Internal-combustion engines. 14,848.
McCallum, K. C.: Clutches and brakes. 14,343.
MacTaggart, H. H.: Telemotor apparatus. 14,367.
Meats, A. G.: Converting reciprocating into rotary motion. 14,573.
Midgley, S. R. E.: Steam, hydraulic, &c., joints. 14,565.
Miller, S. G.: Belt-rail tractor tracks. 14,570.
Markham, H.: Self-locking nut and washer. 14,198.
Martinez, M.: Screw for locomotion. 14,089.
Menco-Elma Syndicate: Speed-changing, reversing, and braking gearing. 14,117.
Morris, C.: Valve-spring lifters. 14,091.
Murfitt, C. J.: Heavy-fuel carburettors. 14,173.
Moffat, J. W.: Electric furnaces. 14,466.
Mabon, J. C. F.: Production of liquid-fuel burner parts, &c. 14,920.
Mabon, J. D.: Production of liquid-fuel burner parts, &c. 14,920.
McKechnie, J.: Pistons. 14,766.
Maguire, F.: Heavy-oil carburetting-systems. 14,900.
Mason, P. J.: Method of lubricating pinions. 14,718.
Mead, A.: Gas-heated furnaces. 14,864.
Menchen, J.: Couplings. 14,696.
Mercer, A. A.: Heavy-oil carburetting-systems. 14,900.
Midgley, A. H.: Dynamo-electric machines. 14,886.
Murray, T. B.: Mechanical-feed lubricators. 14,919.
Nettleton, L.: Gas and air injector apparatus. 14,192.
Nettleton, L.: Gas furnaces. 14,193.
Niblett, H.: Internal-combustion engines. 14,299.
Nordstrom, S. J.: Lubricated hydraulic plug valve. 14,174.
Oliver, C. E.: Pumps. 14,561.
Olsson, C. A.: Pulley-blocks. 14,180.
Owen, J. A.: Valves and valve motion. 14,094.
O'Byrne, T.: Smoke-condenser. 14,815.
Okell, A. P.: Joint pins for driving-belt fasteners. 14,974.
Oulianine, S.: Gyroscopes. 14,951.
Oulianine, S.: Relay commutators. 14,960.
Peterson, L. A.: Change-speed gearing. 14,336.
Pitt, J. D.: Multi-cylinder internal-combustion engines. 14,482.
Portland Engineering & Traction Co.: Motor-driven vehicles. 14,393.
Prince, W. H.: Rotary internal-combustion engine. 14,376.
Pannetier, A.: Water-tube steam-boilers. 14,067.
Paterson, T. W.: Removing carbon deposits. 14,184.
Pollard, G.: Speed-changing, reversing, and braking gearing. 14,117.
Parsons, Sir C. A.: Lubrication of sliding couplings. 14,701.
Portham, R. S.: Marine propulsion. 14,698.
Prignol, H.: Two-stroke-cycle explosion motors. 14,811.
Pullinger, T. C. W.: Securing sparking-plugs. 14,827.
Remington, A. A.: Reversing multi-cylinder engines. 14,480.
Remington, A. A.: Valves and valve-mechanism. 14,481.
Remington, A. A.: Multi-cylinder internal-combustion engines. 14,482.
Ricardo, H. R.: Valves and valve seats. 14,628.
Robinson, M. W.: Belt-rail tractor tracks. 14,570.
Rokes, J. M.: Tools for threading tubing, &c. 14,426.
Rankin, T. T.: Valves and valve motion for engines. 14,094.
Richmond, A.: Valves and valve motion for engines. 14,094.
Riper, L. C. van: Internal-combustion engines. 13,992.
Riper, L. C. van: Internal-combustion engines. 13,993.
Riper, L. C. van: Internal-combustion engines. 13,994.
Roberton, C. G.: Starting internal-combustion engines. 14,837.
Roberts, D.: Piston-rings. 14,689.
Sinclair, B.: Carburettors. 14,133.
Soc. Clerget, Blin, et Cie: Engine, &c., connecting-rods. 14,538.
Soc. des Etablissements Malicet et Blin: Ball bearings. 14,409.
Stevens, A. J.: Motion-transmitting devices for carburettors. 14,647.
Stevens & Co., A. J.: Motion-transmitting devices for use with carburettors. 14,647.

Submersible & J. L. Motors Ltd.: Electric motors. 14,417, 14 423.
Submersible & J. L. Motors Ltd.: Combined pumps and electric motors. 14,422.
Sutton, O. M.: Multi-cylinder internal-combustion engines. 14,536.
Sweetser, G.: Force pumps. 14,575.
Shah, M. K.: Liquid-measuring apparatus. 14,973.
Sheppy, C. L.: Lubricating systems. 14,823.
Silvester, T. E.: Starting-mechanism for internal-combustion engines. 15,006.
Soc. Anon. pour l'Exploitation des Procedes Westinghouse-Leblanc: Steam-ejectors. 14,816.
Stone, G. de Holden-: Fluid-pressure turbines. 14,896.
Sumpter, C. L.: Protecting water-cooled engines. 14,783.
Sutherland, W. C.: Starting-mechanism for internal-combustion engines. 15,006.
Shaw, H. S. Hele-: Hydraulic clutches. 14,107.
Siddeley, J. D.: Internal-combustion engines. 14,023.
Sinclair, J.: Carburettors. 13,983.
Smith, C. M.: Power-transmission gear. 14,134.
Stone, J. D.: Lubricators for grease. 13,959.
Sugden, T.: Steam-superheaters. 14,255.
Sunbeam Motor Car Co.: Oil-filters for engines. 14,143.
Swoboda, A. P.: Carburettors. 14,017.
Triumph Cycle Co.: Friction clutches. 14,212.
Tennant, G. E.: Fuel-economisers. 14,956.
Tonks & Sons, E., A. E., C. W., E., and G. A.: Sparking-plugs. 14,663.
Tebbs, H. E.: Taps or cocks. 14,596.
Thomas Transmission Ltd.: Multi-cylinder internal-combustion engines. 14,536.
Tate, T.: Emergency safety valves. 14,930.
Ussher, L.: Valves, cocks, &c. 14,577.
Vandervell & Co., C. A.: Dynamo-electric machines. 14,886.
Vernaz, A.: Belt-fasteners. 14,702.
Vickers Ltd.: Pistons. 14,766.
Vanderlip, W. B.: Generating power. 14,046.
Viola, E. O. F.: Clutches. 13,987.
Weaver, H. W.: Water-coolers. 14,871.
Willey, S. J.: Generating-boilers. 14,711.
Wood, W. A. E., and W. G.: Vaporisers for internal-combustion engines. 14,682.
Wade, H.: Winding-machines. 14,505.
Wakefield, Sir C. C.: Force-feed lubricators. 14,540, 14,541.
Wiesengrund, B.: Geared turbine installations. 14,320.
Wilkinson, G.: Coal-fired steam-boilers, &c. 14,612.
Williams, G. P.: Clutch. 14,493.
Wirtz, L.: Change-speed gears. 14,490.
Wirtz, L.: Clutching-device. 14,491.
Witt, D. O. de: Belt-rail tractor tracks. 14,570.
Wolseley Motors Ltd.: Reversing multi-cylinder engines. 14,480.
Wolseley Motors Ltd.: Valves and valve-mechanism. 14,481.
Wolseley Motors Ltd.: Multi-cylinder internal-combustion engines. 14,482.
Wood, H. N.: Coal, &c., cutting-machines. 14,349.
Wright, C. R.: Steam-generators. 14,359.
Ward, E. C.: Valves. 14,020.
Watkinson, W. H.: Internal-combustion engines. 14,190.
Weir, G. & J.: Duplex pumps. 14,131.
Weir, G. & J.: Steam-jet air-ejectors. 14,132.
Weir, G. & J.: Steam-jet air-ejectors. 14,258.
Willey, S. J.: Means for combustion. 14,052.
Wright, G. A.: Manufacture of air and water-cooled cylinders for internal-combustion engines. 13,960.
Zeitlin, J.: Cooling-devices for internal-combustion engines, &c. 14,535.
Zeitlin, J.: Internal-combustion engines. 14,818.

## COMPLETE SPECIFICATIONS ACCEPTED.

**1914.**

16,410—Anzani: Four-cycle explosion engines.

**1915.**

4,055—Fowler: Gravity-feed devices for boiler feed-water.
12,360—Johnston, & Globe Pneumatic Engineering Co.: Rotary compressors and exhausters.
13,904—British Thomson-Houston Co.: High-frequency dynamo-electric machines.
13,912—Neuland: Electro-magnetic power transmission apparatus.
14,160—Neuland: Dynamo-electric machines.
14,216—Walker: Dynamo-electric machines.
14,241—Scarborough: Valve mechanism.
14,271—Hult & Hult: Air-cooling means for internal-combustion motors.
14,277—Brooke: Steam injectors.
14,365—British Thomson-Houston Co.: Fluid-pressure valves.
14,377—Neuland: Dynamo-electric machines.
14,412—Willadsen: Reversing-mechanism for internal-combustion engines.
14,435—Bunting: Bearings.
14,492—Uhde: Cooling-towers.
14,527—Sanderson & Wood: Pistons.
14,610—Torrens: Carburettors.
14,633—Heys: Dynamo-electric machines.
14,643—Heys: Dynamo-electric machines.
14,650—Shaw, Shaw, & Sharp: Alternating-current electric motors.
14,657—Robinson: Steam superheaters.
14,760—Blane: Pedestal end bearings.
14,796—Sowden: Vacuum pumps.
14,851—British Thomson-Houston Co., & Ralph: Magneto-electric machines.
14,885—Heenan & Froude Ltd., Heenan, & Walker: Dynamometers.
14,924—Petter: Controlling supply of liquid fuel.
14,967—Svenska Aktiebolaget Gasaccumulator: Valve-operating means.
15,139—Bergasse: Carburettors of internal-combustion engines.
15,769—Gresley: Valve-gear for locomotives.
15,827—Grange Iron Co. & Hoyle: Apparatus for washing coal.
15,941—Carter, & Hans Renold Ltd.: Driving-chains.
16,640—Electromotors Ltd., Longbottom, & Greenhalgh: Dynamo-electric machinery.
16,660—Bosch: Rotary pump.
17,483—Roberts: Forced draught systems for marine boilers.
17,590—Morison: Steam-condensing plant.
17,833—Wilson, Andersen, & Curtis: Systems of electric welding.
18,137—Martin: Dynamo-electric machines.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

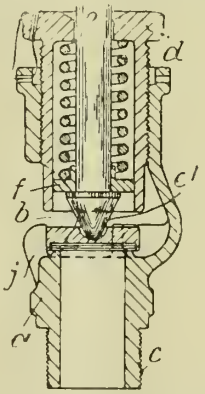
**1916.**

201—Concaris, A.: Valve gear. **100,097.**
451—Comings, W. R.: Seatings for valves. **100,020.**
589—Westinghouse Brake Co.: Fluid pressure braking-apparatus. **100,881.**
594—Belliss & Morcom Ltd., and Guest, C. L.: Centrifugal-governor mechanism. **101,644.**
1,091—Jarvis, E. H., and Bradbury, H. W.: Air pump. **101,736.**
1,579—Henderson, T.: Internal fittings for boiler tubes. **101,572.**
2,409—Price, A., Pryse, W., and Morgan, F. J.: Petrol and other internal-combustion engines. **101,654.**
4,167—Thompson, C. H.: Furnaces. **101,757.**
4,421—Southall, J.: Internal-combustion engines. **101,661.**
5,240—Lamkin, A. E.: Sparking-plugs. **101,592.**
5,896—King, C. F. L.: Carburetting-systems. **101,668.**
6,015—Clinton Cam Co.: Cams. **101,669.**
6,577—Johnson, E. W.: Carburetting-apparatus. **101,597.**
6,824—Robinson, R. P.: Vaporisers for internal-combustion engines. **101,600.**
6,934—Davey, H.: Compound condensing steam-engines. **101,673.**
7,338—Kilburn, B. E. D.: Engine cylinder. **101,603.**
7,517—Lamkin, A. E.: Sparking-plugs. **101,678.**
7,547—Lund, H. J.: Apparatus for cleaning boilers. **101,679.**
9,162—Winter, G. B.: Artificial fuel. **101,609.**
9,340—Morgan, J. H.: Pulley for belt gearing. **101,774.**
10,224—Coleman, A. B.: Pipe connections or fittings. **101,689.**
10,372—McGregor, D.: Carburetters. **101,690.**
10,389—Miller, H. P. E., and Tetlow, E.: Valve mechanism. **101,776.**
11,038—Caterpillar Tractors Ltd.: Traction engines of the self-laying track type. **101,692.**

## ABSTRACTS OF SPECIFICATIONS.

### SAFETY VALVES.

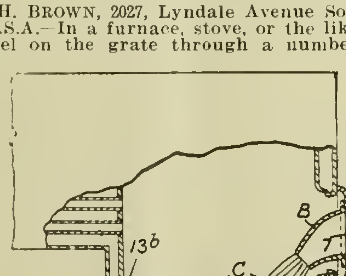
101,129.—F. M. BAILEY and W. B. DALE, Albion Works, Salford, Lancashire.—April 15th, 1916, No. 5545.—A spring-loaded relief valve comprises a loose valve member guided by webs *j* formed on a casing *a* having a side outlet opening *b* and an externally threaded inlet connection *c*. The spring is adapted to bear against a washer *f* carried by a spindle *e* provided with a conical




head *e*1 adapted to engage a recess on the back of the valve member. The washer is a sliding fit within the hollow adjusting screw *d*, and so prevents the exhaust from coming into contact with the spring. The screw *d* is secured in its adjusted position by a sealed wire passed through a hole in the screw and through one of a series of holes formed in the casing.

### FURNACES.

101,172.—W. H. BROWN, 2027, Lyndale Avenue South, Minneapolis, Minnesota, U.S.A.—In a furnace, stove, or the like, air is supplied above the fuel on the grate through a number of curved and




downwardly-directed tapering tubes passing through the double walls of the firebox. The fire door may also be provided with a somewhat similar air-supply tube. Fig. 1 shows a boiler furnace

of the locomotive type wherein the air-supply tubes C are provided with a bead or flange 13b engaging with the inner wall of the firebox, and the inlet ends of the tubes are rolled into the outer wall at 13a. The fire door 7 is provided with openings 8 delivering into the tube B, which is secured to the door by the flange 10.

### GAUGES.

101,181.—A. Hart, 61, Leagrave Road, and K. J. Almfelt, 3, Norman Road, both in Luton, Bedfordshire.—Instruments wherein the movement of a sliding pin is transmitted to a pointer by an intermediate lever are provided with a variable ratio of transmission between the pin and the pointer by change of the position of a member connecting the lever and the pointer. The motion of a sliding pin *d*, Fig. 2, is transmitted to a pointer *b* by a lever *c* pivoted at *f*, the pointer and lever being formed with a series of knife edges *s t*, between any pair of which a block *i* may be interposed. The block *i* is carried by an arm *j* pivoted at *k* to a vertically sliding plate on the front of the instrument, by which the block may be set as required. The knife edges may be dispensed with, the block making contact with any pair of points on the lever and pointer. In a modification, Fig. 5, a bell-

FIG. 7. FIG. 2. FIG. 8.

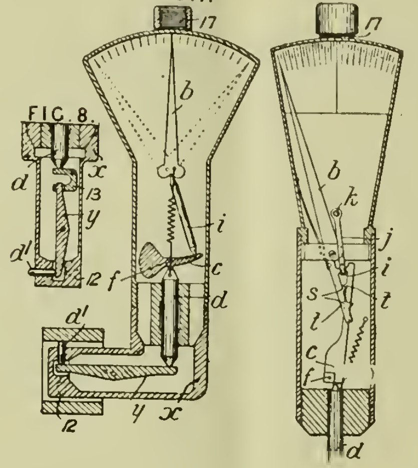
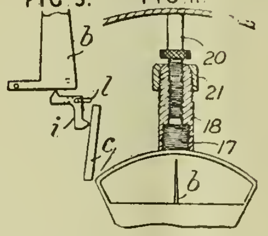



FIG. 5. FIG. 11.




crank lever *i* is pivoted in a slot *l* so that its leverage may be varied. In another form, a short strut is pivoted to the lever *c* and is formed with a knife edge to bear at various points on the pointer *b*. Fig. 7 shows a modified form of lever *c* and pointer *b* connected by a strut *i*, which may be moved along the lever, provision being made for effecting adjustment from without. An adaptor *x* for internal measurements comprises a lever *y* bearing at its ends on the pin *d* and another sliding pin *d*1 acting in conjunction with screws 12. Fig. 8 shows a similar device a V-shaped lever 13 being introduced to bring the pins *d d*1 at right angles; or these pins may be directly connected by a bell-crank lever. An adjustable extension 20, Fig. 11, may be fitted by means of a sleeve 18 screwed on a nipple 17 and slotted so that the stem 20 may be clamped by a nut 21.

# Queries and Replies.

We shall at all times be pleased to help our readers out of their difficulties to the best of our power, and invite them to make use of this column for that purpose.

F. W. H. (Colchester).—Our publishing department can supply you with "Heating and Ventilation," by C. L. Hubbard, 6s. net, and "The Economic and Commercial Theory of Heat Power Plants," by R. H. Smith, 24s. net.

A. B. (Exeter).—We have no information.

J. W. H. (Leeds).—Yes, the arrangement you suggest should be quite satisfactory.

Power (Bristol).—Further information on the same subject will shortly appear in our columns.

# INDEX TO ADVERTISERS.



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THE
# Industrial Engineer.

Vol. V.] NOVEMBER 22nd, 1916. [No. 123.

## The Industrial Engineer.

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### CONTENTS.



# EDITORIAL.

## LABOUR AND MACHINERY IN THE UNITED STATES.

It has been said over and over again in the general press of the country and by a great many public speakers that great changes will take place in the conduct of industry after the war. Such statements are beginning to be recognised as truisms, for the simple reason that changes are taking place now which point the way in an unmistakable manner to the later changes which have been referred to. One of these changes will be the increased use of machinery and the gradual evolution of present-day machinery in the direction of greater automaticity. And again, the finding of new industrial applications, both for present-day machinery and for that which will be devised. All these are steps in the right direction, and it does not necessarily follow that the increased use of machinery will bring within its wake a decrease in the number of workers employed. It will be the other way about for a very long time to come, certainly for so long that most people now living need not trouble about the results to them.

### Conditions in the United States.

We in this country are not by ourselves in wakening up to the possibilities of machinery. The United States has been fully alive to the matter for a long time. Engineers and others there, are, however, at the moment faced with the problem of labour shortage, which is tending more and more to cause them to concentrate upon the increased use of labour-saving machinery.

So great is the scarcity of labour throughout the country that Eastern (U.S.A.) interests, including railroads, are striving in every way possible to tempt labour away from the South. Western iron interests are taking men from the Birmingham (Alabama) district. Eastern railroads, acording to Savannah reports, have recently taken more than a thousand negroes from that section on special trains, while efforts are being made to get other thousands away. The struggle for labour is the fight of the hour in the United States, and, as immigration will probably be small for some years to come, the contest for labour will grow in intensity.

Only through the largest utilisation of labour-saving machinery of every kind will it be possible for manufacturers there to meet this labour shortage without serious loss. They recognise that whilst we in Europe are bending every energy toward the highest possible efficiency in death-dealing devices, it should be their effort to bend every possible energy to the highest development of labour-saving improvements in order that manual labour, wherever feasible, be supplanted or aided by mechanical labour. In doing this the labourer is benefited and the industries of the country saved from a situation which seriously threatens their continued expansion and prosperity.

Manufacturers of the country are urged not to wait until the labour shortage has become so acute as to endanger their business, but to begin now to work out plans for labour-saving devices wherever this can be done to advantage. The engineers and the machinery dealers of the country are invited to turn their attention to a study of new ways of lessening the amount of manual labour and of creating new forms of machinery or new adaptations of equipment or inventions to take the place of manual labour.

One leading (U.S.A.) trade magazine says:—

"We have, with our accustomed national spirit of vain-glory, boasted of our ability to capture the world's trade away from Europe. In this we have aroused the resentment of the nations of Europe, who feel that while they are fighting a life-and-death struggle we are trying to stab them in the back by boasting of our ability to capture from them the trade upon which their prosperity depends. We are making no friends, but many enemies, by this vain-glorious boasting. At the close of the war Europe will be stimulated by its necessities as never before to produce at the lowest cost. Its industries will have developed an efficiency never dreamed of before, and back of all of this will be the spirit to conquer the world trade against us, stimulated not only by their necessities, but by our threats to take the trade from them. The people of this country do not seem to have measured this situation properly from any standpoint, either that of industrial preparedness or of national preparedness."

# EVOLUTION IN VENTILATION HYGIENICS.

By James Keith, A.M.I.C.E., M.I.M.E., M.I.Mar.E., Etc.

*(Continued from page 46.)*

## 5.—SUBWAY OR UNDERGROUND RAILWAY VENTILATION.

To do this important subject justice would require that it should have a paper all to itself, and it can therefore only be briefly dealt with here. A study of the history of the main underground railway of London from its inception in 1863 down to the present day will be found not only interesting, but instructive, so far as regards the ventilation of underground railways and "tubes" or "subways" and the advance that has been made in that direction within the past fifty odd years, if not during the last 20 or even 10 years.

At first no special provision was made for ventilation. Hot-water locomotives were intended to be used, but were really never applied, and consequently coal or coke-fired steam locomotives were used for traction; hence the ventilation of the tunnel sections of the London Underground Railway was bad from the start, even when the traffic was comparatively small. Within the past 10 years, however, the Metropolitan and District Railway has been transformed into an electrically-worked line, and it is now the best underground railway of its kind in existence, so far as ventilation is concerned. This comfortable state of affairs, having been secured under English climatic conditions without mechanical ventilation, requires some special explanation

### The London Metropolitan

Unlike the London deep "tubes," but like the Paris and New York "undergrounds" or "subways," the tunnels of the London Metropolitan main underground railway are only a few feet under the level of the streets. The tunnels are of large dimensions, while the stations are on an average about half a mile apart, and most of them have now been opened up to the outside air with large open spaces on each side. Thus, it has been found that under these newer conditions and with electrical traction, the movement of the double-track trains travelling in opposite directions keeps the air of the tunnels in sufficient motion to prevent stagnation, or the existence of the deleterious uniform or "windless" atmosphere so much complained of by hygienic authorities, and so gives good ventilation and a feeling of freshness all the year round.

On the contrary, like the deep London "tube" railways, but unlike the main London Underground Railway, the "undergrounds" or "subways" of Paris and New York are generally unprovided with open stations or with spaces or areas throughout the lines entirely open to the outside air, and although electrically worked and otherwise well equipped, cannot by any stretch of imagination be described as well ventilated.

As regards ventilation, these Paris and New York lines were designed to work on practically the same principle as that originally applicable to the deep London "tube" lines —*i.e.*, the "piston action" of the trains when running was fallaciously expected to be sufficient for the perfect ventilation of the tunnels.

Formerly, in connection with the ventilation of railway tunnels in which there was steam traction (with smoke and products of combustion to be got rid of), it was considered essential to extract the vitiated air from about the centre of or between stations, the fresh air being allowed to flow in from each station or from each end of the tunnel. Recent experience, however, has demonstrated that where there are no smoke and products of combustion to contend with the best results are obtainable by the plenum system, say, by flooding a tunnel (worked by electrical traction) with fresh air drawn in volume from above and delivered below under slight pressure from the centre, the vitiated air being thus expelled at the tunnel ends.

It will be seen, therefore, that the case of the Metropolitan and District Railway is to be regarded as an exception on account of the exceptional circumstances.

### Ventilation of the Deep London Tubes.

The ventilation of the deep London "tubes," however, offers quite a different problem for solution, and this can only ultimately and effectively be accomplished by the application of the same principle as that which has been found to be so satisfactory in the case of engine rooms on board

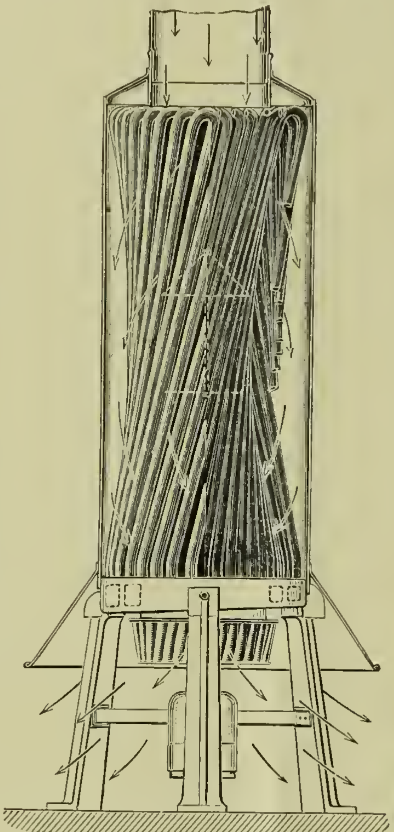


Fig. 15. Ventilation Hygienics. Fig. 16.

big ocean liners and which has already been so fully explained. Considerable improvement has already been effected within recent years by the introduction of fresh air at some of the stations from the surface under pressure by mechanical means, but, in the author's opinion, much more still requires to be done, but on somewhat different lines.

### New York Subways.

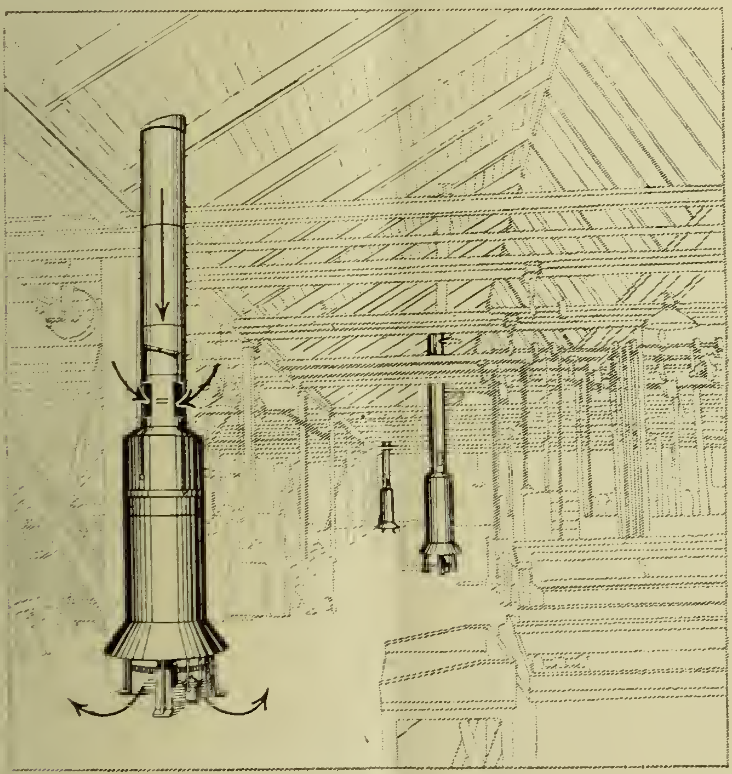
Indifferent though the ventilation of the London deep "tubes" may be, however, it is excellent in comparison with that of the New York "subways," which in summer time have an atmosphere of the most oppressive kind; curiously enough, too, tobacco smoking is forbidden in these New York "subways" under a heavy fine, as if disinfectant tobacco fumes were believed to render the germ-laden atmosphere more harmful, whereas with good ventilation tobacco smoking ought to be beneficial.

Notwithstanding the usually overcrowded condition of these New York "subways," producing causes of discomfort (aggravated by the odour and heat generated from the running of hundreds of electric motors), there is no reason why the air should not be as fresh and healthful as that of the open, wide streets immediately above, provided a proper system of mechanical ventilation were installed. As a matter of fact, the outside air of New York is, as a rule, particularly bracing and exhilarating, in marked contrast with the inside air, which goes so much to make "the pale, undeveloped, neurotic, and joyless citizen." With fresh air immediately above, it appears surprising that more advantage of it has not been taken to make the atmospherical conditions of these convenient "subways" more in keeping with hygienic conditions.

### Air Moving Steadily and Softly.

A volume of air moving steadily and softly at the rate of from four to five miles an hour has only an infinitesimal water gauge, but at the same time it is all-sufficient, if the motion be maintained for the purpose of ventilation, so that a zephyr of this description, as advocated (with any chill, even in winter, taken off in its passage from the centre to each station), carrying on its wings freshness and purity, ought to make things brighter, more healthy, and more enjoyable for those who have to spend so much of their lives travelling in such underground channels.

The author has come to the conclusion that for such underground ventilation there is no necessity (unless in very special circumstances) to wash or cool, or even to screen, the air. No reasonable person expects or will ask for better atmospheric conditions in these underground highways than are to be found in wide, healthy streets or roadways above ground, conditions which can undoubtedly be obtained by the proper application of the method suggested and which conditions are undoubtedly specially applicable to the New York "subways."



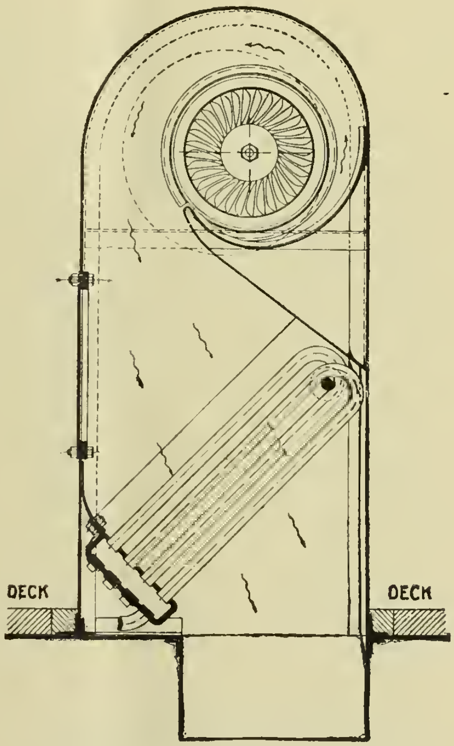
Ventilation Hygienics—Fig. 17.

## 6.—WARMING AND VENTILATING BY CONDUCTION AND CONVECTION.

It being equally necessary on the score of health to be able to furnish at times an abundant supply of fresh air sufficiently warmed to provide heat as well as ventilation without objectionable draughts, quite different applications become essential.

Figs. 15 and 16 represent respectively a part vertical section, part elevation, and an elevation with the outer casing removed of an open fan combination electrically driven, capable of furnishing and equally distributing fresh air mechanically, either heated or cold. If heated the air is preferably delivered at or towards the floor level. The same unit may also be most effectively used for circulating or part circulating the air of the apartment as illustrated by Fig. 17.

As shown by the diagrams, the apparatus is designed to rest on the floor, but naturally it may also be constructed for erection at a higher level. In either case the appliance may be connected to a fresh air duct coming down through the roof or from the upper portion of a building in which may be arranged a bye-pass and damper to permit the air in the apartment, or a portion of it, to be re-circulated at option as indicated on Fig. 17.




Ventilation Hygienics—Fig. 18.

For furnishing fresh air, cooled or warmed or diluted, from the upper deck of a modern ocean liner and delivering it under moderate pressure into state-rooms, saloons, etc., below, quite a different arrangement is called for. Fig. 18 shows a transverse section of what may be called a plenum ventilating cased fan installation for effectively performing the work described. This arrangementment is to be distinguished from constructions which require air to be forced through small tubes, absorbing more power, and by which a large proportion of the initial volume of air is practically lost. In the form illustrated the fan draws in the fresh air, propels it downwards and freely around heated or

cooled surfaces, and compresses it only to the delivery pressure necessary for the main duct, there being thus no loss in air volume between the fan outlet and the inlet to the main air duct beneath the deck, while the air delivered, being in no way wire drawn or initially overheated, naturally remains in a much fresher condition. With an arrangement of this sort it is possible to obtain a very high efficiency; for example, with, say, a difference of 40 deg. Fah. between the temperature of the outside air in cold weather and that of the air delivered into the main deck ducts, every 1,000 cubic feet of the air so delivered, at a constant water-gauge pressure of 2 in., has been found in practice only to require for electrical current the expenditure of about ½ H.P., which shows a very high mechanical efficiency indeed.

This particular arrangement has been installed on board the latest Canadian Pacific liners, as well as on the latest Cunarder, the "Aurania."

(*To be continued*).

## RUSSIAN ASBESTOS INDUSTRY.

Asbestos is found in insignificant quantities in the Caucasus and in Siberia, but about 99 per cent of the Russian output is mined in the Ural Mountains. Some of the best asbestos mined in the Urals is produced at mines 60 miles north-west of Ekaterinburg, in a zone of serpentine rocks which extends about six miles and is about 1,400 yards broad. The quality of this asbestos is believed to be as high as that of Canada and Piedmont. The veins are directly broken off, either by hand or by a hard hammer. The operation of mining asbestos in the Urals is of a primitive character, but in some cases the production is being made more systematic.

According to a report by the United States Consul-General at Moscow, the most important of the Ekaterinburg asbestos mines are the Vosnesensky and Zoe-Anensky asbestos mines, situated 19 miles from the station of Bazenhof, on the Perm-Tiumen Railway. A third of the asbestos produced in the Urals is obtained here, and all the asbestos produced was dispatched abroad, untreated, through Reval. The Shchelkovy asbestos mines in the village of Mostovsky produce less than the above mines, all the asbestos produced being worked up in the factory, where sheeting, bands, twine, insertion, thread, etc., are made. The Gavorikhinsky asbestos mines lie in a line with the Voznesensky mines, and yielded 3,183 tons of asbestos in 1911. Six miles from the Meivo-Shaitansk factory of the Alapievsky Mining Works are the Kirtanovsky asbestos mines, with a sorting factory where 2,000 tons of asbestos can be sorted per annum. Close to these mines are the mines of the Russo-Italian Asbestos Co., the N. V. Mikhanov Co., the "Uralite" Co., etc. The following figures show the output of the Ural (Ekaterinburg) asbestos from 1906 to 1913: 1906, 8,001 short tons (of 2,000 lbs.); 1907, 8,743 short tons; 1908, 10,694 short tons; 1909, 13,129 short tons; 1910, 10,936 short tons; 1911, 15,872 short tons; 1912, 16,584 short tons; 1913, 16,661 short tons. Practically the whole of the output was exported *via* Riga.

North of Ekaterinburg asbestos is found in the Bogolsof mining area, in the Kortiakovsky mines (where the vein is about 2 ft. thick), near the Alapievsky works, the Verliansky works on the River Ukhtesa, near the Beresovka works, etc. In the Southern Urals asbestos deposits are found at the Khristogor and Petropavlovsky ore mines, near the Miask works on the River Kresnucht, in the Pavrilof copper mines (of excellent quality), in the Athansky gold placer, near the River Iman Yurt (in talcous schist); there are veins of asbestos near the Kisnikaievsky copper mine at the foot of the Naralinsky Hills; also amongst the serpentine of the River Kara, near the Kachinsky factory, and along the River Puberle, near the fort of that name.

The best mineral is considered to be that of the Asbestovoy Hill, on the River Sissert, and the asbestos deposits of the Shelkovoy Hill, on the land of the Nizhni-Tagil works, between the Shouralinsky and the Teploy Hills. To the south of the Ural range of hills in the Government of Orenburg there are some exploited asbestos mines—the Natalievsky in the Upper Ural district—the Issergansky in the Orsk district, and the Kholmisty in the Troitzk district.

The following companies have joined the syndicate of Ural asbestos producers:—

| | Tons |
|---|---|
| 1. Voznesensky Asbestos Mines, with an annual output of | 3,106 |
| 2. Yakovlev Successors, with an annual output of | 1,806 |
| 3. Poklevsky-Kozell Successors, with an annual output of | 5,416 |
| 4. Korovo Asbestos Mines, with an annual output of | 2,709 |
| 5. Girard de Soukanton, with an annual output of | 3,611 |
| 6. Russo-Italian Asbestos Mining Co., with an annual output of | 1,806 |
| Total | 18,454 |

It is stated that all the companies operating in this district are privately owned and managed. The present transport facilities from the mines are confined to the single-track line of the Perm Railway, connecting with the Northern Railway to Petrograd.

According to official statistics, the exports of asbestos from Russia for the last seven years were as follows: 1909, 9,160 short tons; 1910, 9,689 short tons; 1911, 13,524 short tons; ; 1912, 15,547 short tons; 1913, 13,669 short tons; 1914, 8,577 short tons; 1915, 975 short tons. These exports before the war went to Germany, Austria, the United Kingdom, Belgium and the Netherlands. Asbestos is produced in the Caucasus in an insignificant quantity, in the Sharopan district of the Kutais Government, at the Vzhinevi asbestos mines. In the same Government of Kutais asbestos is known to exist far from the deposits already named to the north-west, in the Lechgoumsky district in the Savanetsky police circuit. It is also found in the extreme south-eastern corner of the Caucasus, not far from the Persian frontier, 12 miles from the town of Shusha.

In Siberia asbestos is exploited only in the Government of Irkutsk, in the Angar district, at the Angar asbestos mines. In the Government of Yenisei there are asbestos mines on the left bank of the River Kamuisht, near the Saksar and the Ak-kay Hills, near Bishtals Hill, at a distance of 25 miles from the village of Askeisk, and on the River Karagan, on the boundary of the Maisky and Servievsky gold placers. In the Tomsk Government it is found in the system of the River Katum, in the Semiriechensk territory, on the northern slope of the Dzhigla Range, in the Dzuban-Arychsky district, and in the Transbaikal Province, in the serpentine of the Klinchinsky ore mine, near the Shilkinsky factory, and in the neighbourhood of the tin mines of the Nerchinsk Circuit.

On the Mongol-Dabansky gold placers (now worked out), which belong to the Crown, very rich asbestos and mica mines have been discovered. The Mongol-Dabansky gold placers are situated on the River Mongol-Daban, which falls into the River Didi, a tributary of the River Oka. The new mines lie 75 miles from the station Zima, on the Trans-Siberian Railway.

## THE USE OF POWDERED COAL IN METALLURGICAL PROCESSES.

By C. J. Gadd.

(*Continued from page 43.*)

### Another High-pressure Feeding Apparatus.

Fig. 6 illustrates a sectional elevation of a mechanically-operated high-pressure feeding apparatus for powdered coal, which is similar in every respect to that shown on Fig. 5, excepting that low-pressure air of 1 lb. pressure is used to pick up the stream of coal delivered to the burner by the feeding device.

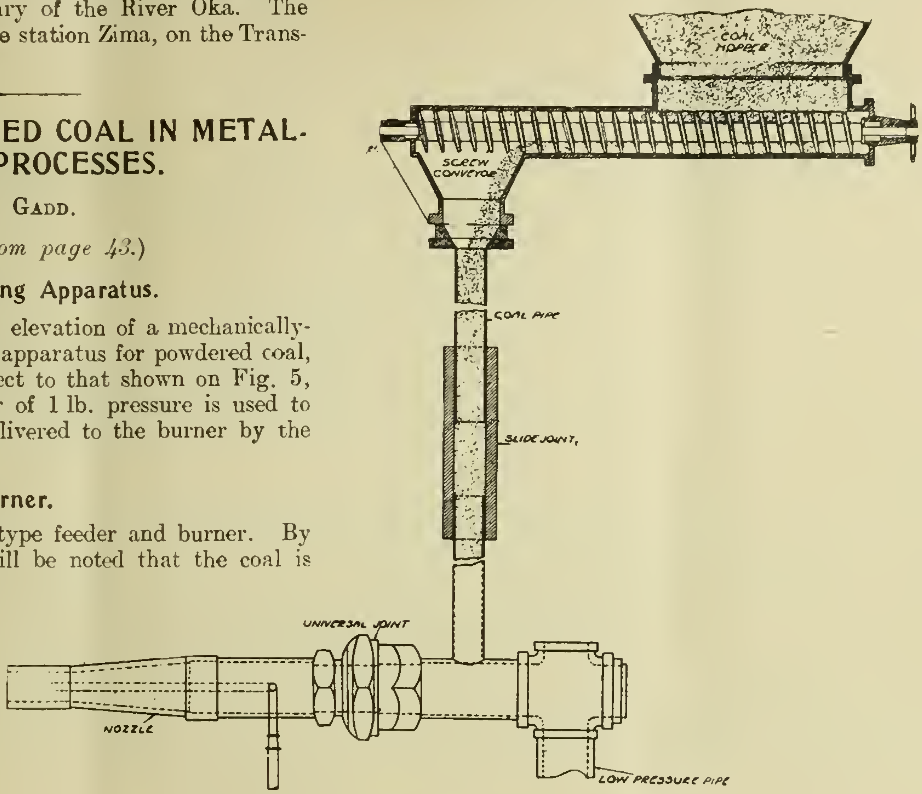
### Syphon Type Feeder and Burner.

Fig. 7 illustrates a syphon type feeder and burner. By reference to the drawing it will be noted that the coal is syphoned from the hopper into the burner and discharged at high pressure into the furnace.

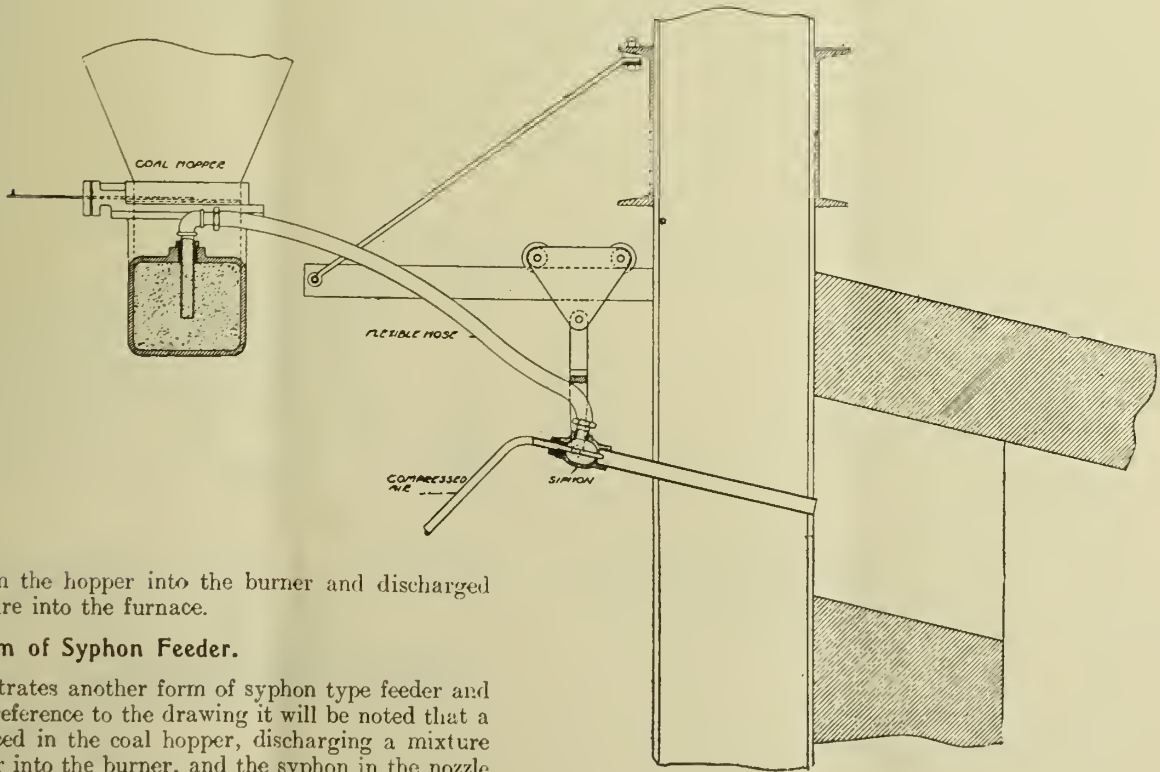
### Another Form of Syphon Feeder.

Fig. 8 illustrates another form of syphon type feeder and burner. By reference to the drawing it will be noted that a syphon is placed in the coal hopper, discharging a mixture of coal and air into the burner, and the syphon in the nozzle of the burner discharges the mixture at high velocity into the furnace.

Feeders and burners of the high-pressure type produce a long flame through progressive combustion and can be used only where the form of the furnace and the character of the




The Use of Powdered Coal.—Fig. 6.




The Use of Powdered Coal.—Fig. 7.

work demand that an elongated cutting flame be developed in close proximity to the work done. This method of application is adapted to open-hearth furnace practice and ore nodulising.

In the type of feeders and burners described it is interesting to note that the results obtained in the combustion of the fuel are equally good, whether the powdered coal is injected into the furnace from the burner at a velocity of 1,500 ft. per minute or of 25,000 ft. per minute.

### Furnaces.

In the metallurgical processes powdered coal has been applied with commercial success to various types of furnaces, such as annealing, puddling, heating, open-hearth, ore nodulising, etc.

In order to ensure success in applying powdered coal to furnaces, no matter what their type may be, one general rule must be obeyed, namely, that it be fed to the furnace at a uniform rate in a thoroughly atomised state, and that the furnace be so designed that complete combustion may take place while the coal is in suspension.

Fig. 9 shows a sectional elevation through a puddling furnace arranged with a return tube waste-heat boiler and equipped for burning powdered coal.

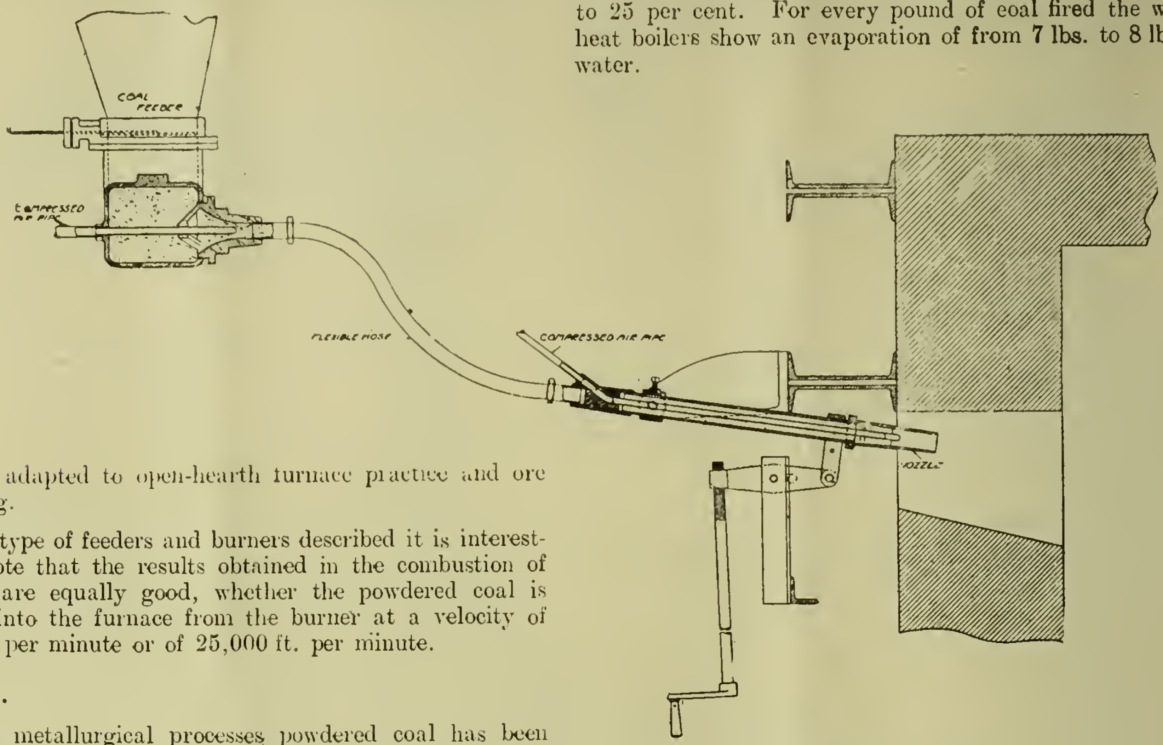
Fig. 10 shows a sectional elevation of a three-door heating furnace of the type generally used in heating iron piles and steel billets, also arranged with a waste-heat boiler and equipped for burning powdered coal.

In both of these installations a low-pressure burner discharges the mixture of coal and air into a combustion chamber. As the fuel combusts the heat thus produced is conveyed over the bath or furnace hearth, as the case may be, and the waste gases pass through the boiler setting to the stack.

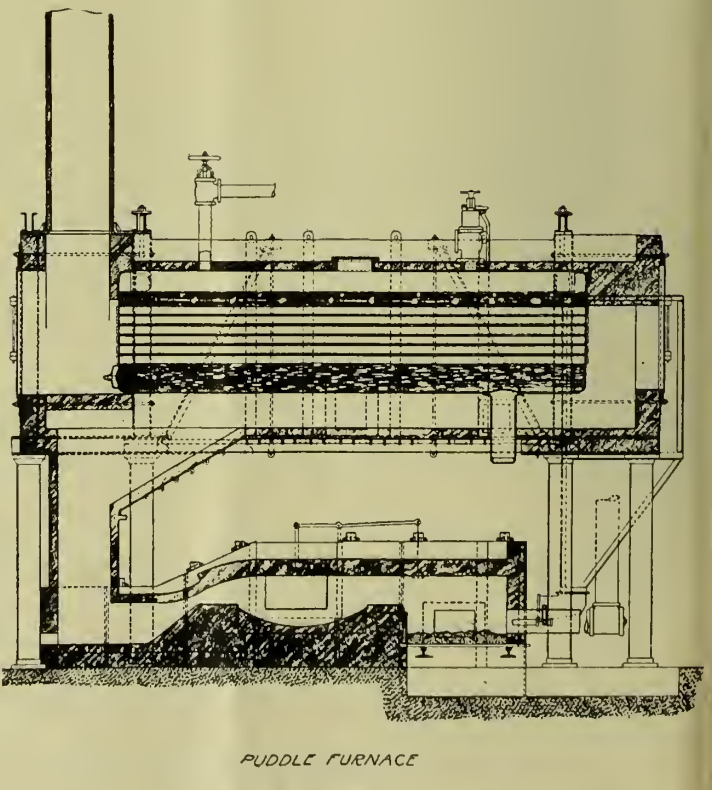
Loose grate bars supporting a bed of about 9 in. of ash form the combustion chamber hearth, and a large portion of the ash contained in the coal collects over this surface. After each heat the accumulation of ash is raked out through the cleaning doors, and once a week the grate bars are dropped and the chamber thoroughly cleaned.

The accumulation of slag at the base of the uptake flue is tapped out from the slag runner. The ash which falls upon the material in the furnace is too small a proportion to cause any ill effect. In the boiler settings and flues considerable ash is deposited in the form of an impalpable powder, which is cleaned out once every 12 hours.

As to the economy of fuel on puddling furnaces, the use of powdered coal has shown an average saving of about 30 per cent to 36 per cent, and on heating furnaces 15 per cent to 25 per cent. For every pound of coal fired the waste heat boilers show an evaporation of from 7 lbs. to 8 lbs. of water.



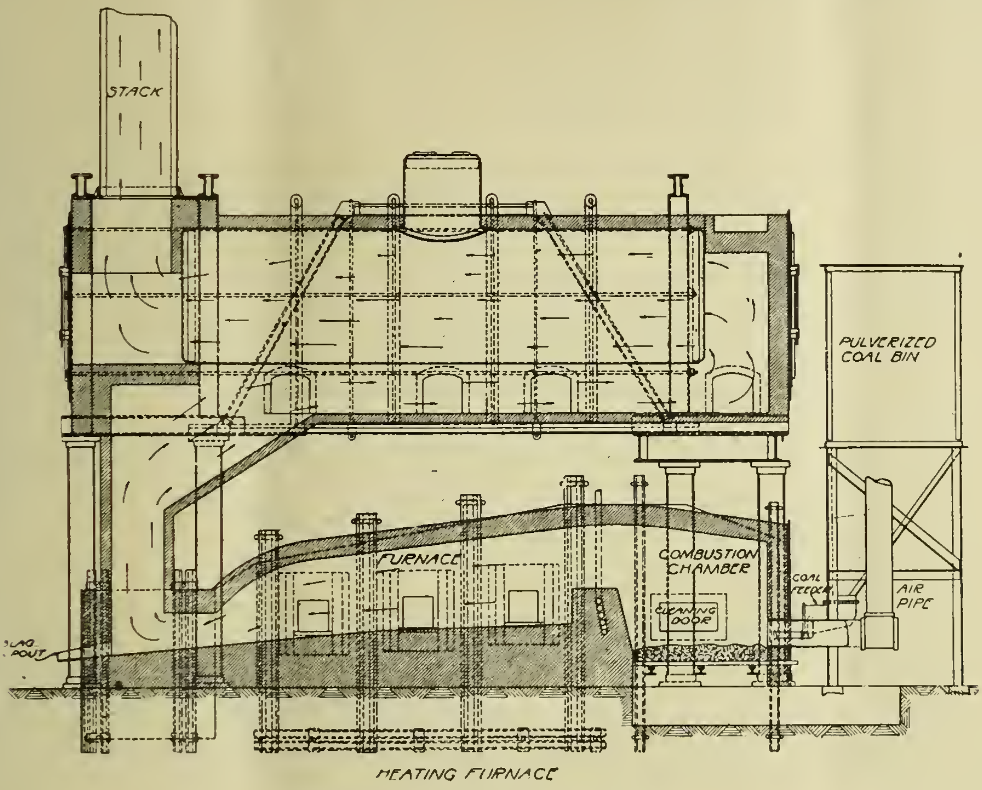
The Use of Powdered Coal.—Fig. 8




The Use of Powdered Coal.—Fig. 9.

Fig. 11 shows a sectional elevation of a continuous heating furnace for heating steel billets, and equipped for burning powdered coal.

*(To be continued.)*




The Use of Powdered Coal.—Fig. 10.

## INSTITUTION OF MECHANICAL ENGINEERS: PRESIDENTIAL ADDRESS.

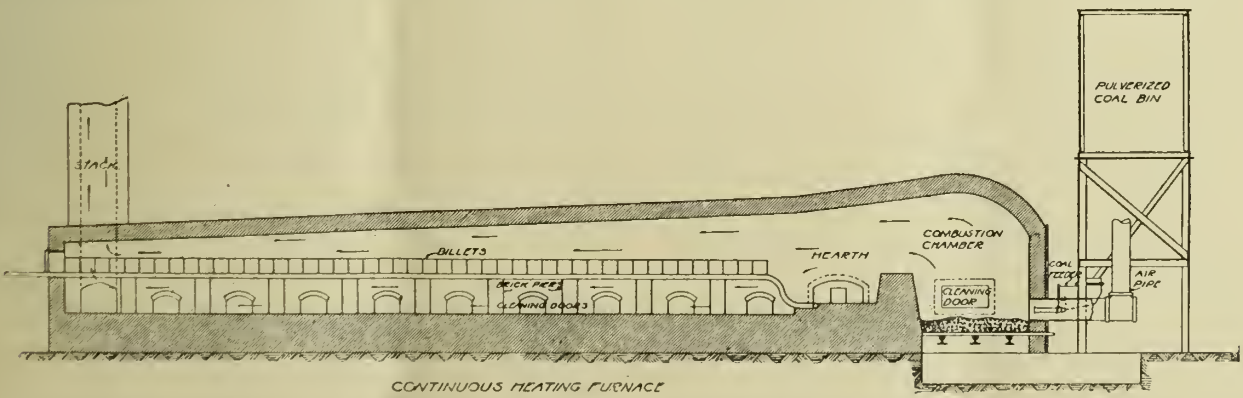
By W. Cawthorne Unwin, LL.D., F.R.S.

*(Continued from page 55.)*

### The Use of German Steel.

Dr. Dugald Clerk says also that the greater part of German steel is used at home. But how far is that true? In 1912 Germany exported a million tons of pig iron and 4 million tons of steel partly manufactured.* In 1913 we imported from Germy iron and steel to the value of £7,500,000, and in addition machinery to the value of £2,300,000.† Take a single article, railway rails. Between 1908 and 1912, only four years, the export of rails from the United Kingdom decreased 10 per cent, that from Germany increased 16 per cent, and that from the United States 22 per cent. In 1912 both Germany and the United States exported more rails than we did. Now the iron and steel industry is a basic industry, the prosperity of it affects almost all other industries. We might get on without a dye industry, but the steel industry is vital.

The impulse to the development of the German iron and steel trade came from the acquisition in 1871 of part of Lorraine, containing 1,800 million tons of minette iron ore, followed by the discovery, in 1877, by Thomas and Gilchrist, of the basic process. Probably Germany expected as one result of the war to annex the still larger iron deposits in the part of France now occupied




The Use of Powdered Coal.—Fig. 11.

* Board of Trade. Iron and Steel, 1912.

† Sir L. G. Chiozza Money.

by her armies. Mr. Ellis Barker has stated that the attack on Verdun was probably due to the wish to deprive France of her iron ore. It is probably true that steel is produced in Germany more cheaply than here. The works are on a very large scale and under the most able commercial and scientific management. German steel is almost exclusively made by the basic process. British steel is made chiefly by the acid process, which requires purer ore, and in fact a large part of our production is from imported ore. I believe we could produce more basic steel, and it is worth consideration whether a prejudice against basic steel justified in early days is now reasonable.

### The System of Kartells.

An influence which, in the opinion of Continental economists, has been powerful in the development of German trade is the system of Kartells, which has been formed since the passing of rigidly protective legislation in 1879. One of them, the Steel Union, embraces 31 firms with an annual output of 12 million tons. Based on mutual consent, it controls the selling price of steel in each district, the area within which each selling agency may supply, the total annual output of each steel works, and the allocation among makers of the profits. It was ostensibly the object of this combination to reduce cost of production by regulating output and abolishing competition between firms in the syndicate. No doubt a less openly confessed object was to acquire selling monopolies and impose its own price on consumers.

### Dumping.

It is alleged that the Steel Union systematically resorts to dumping. In normal trade the price increased with the distance from the centre of production, being loaded with transport and other charges. In dumping the reverse is the case, out of profits made in a protected home market, bounties are given on exports to vanquish competition. For instance, from figures given by M. Milliond, girders and rolled bars sold in Germany at M.130 were sold in England and South America at M.103 to M.110, and in Italy, where it was desired to hamper a struggling industry, at M.75. Sir Robert Hadfield has stated that before the war the export bounty granted by the Steel Union amounted to M.15 per ton. The sale at a low price of an accidental surplus due to over-production is one thing; deliberate over-production in order to defeat competition abroad by dumping is another. Competent observers like M. Milliond believe that that has been the policy of the Steel Union.

Perhaps there is nothing illegal or which contravenes ordinary trade morality in a system of dumping. The Commissioner sent by "The Times" in 1901 to report on "American Competition" states that the American manufacturers openly avowed the intention to keep up prices by stinting the home market in order to force the export trade by cutting prices in foreign countries. Possibly the importance of dumping may have been overrated. Continental economists do not seem to think so. But I do not believe that any nation subjected to systematic dumping will permanently submit to strangulation by an unfair trade method. It is not for me to suggest a remedy. No doubt one can be found, and, personally, I hope it may not interfere with our custom of unrestricted trade.

### Have our Trade Methods been too Individualistic?

To adopt a Kartell system with the protection which is its basis in Germany, would be contrary to our ideas and traditions. But dumping is not an essential part of association in trade. We may recognise that, as Naumann says, in Mittel-Europa "combination means the elimination of wasteful competition, economy of large production and gains from expert buying and selling on a large scale." It is a matter for consideration whether our trade methods have not been too individualistic. There would seem to be advantages in co-operation of firms, not merely to control labour, but in introducing methods of workshop organisation, in pooling commercial and technical knowledge, in uniting in scientific investigations, and in establishing competent agencies in foreign countries. The Engineering Standards Committee is an example of advantages obtained by consultation and compromise without interference with individual freedom, and standardisation of production is likely to be much extended after the war. Mr. Asquith said, "I lay particular emphasis on two tendencies. The first is the development of trade association for common action at home and abroad, raising the average standard of production. The second is the recognition of the leeway we have to make up as regards scientific research and its application to technical and industrial purposes."

### An Engineers' War.

In August, 1914, the Navy was ready, but in other respects we were unprepared for the war which was forced on us. But the way in which our characteristic unpreparedness, slackness, and inertia have been overcome and organisation created is extraordinary. It is an engineers' war, and mechanical engineers can realise the task involved in their department. Four thousand factories are under Government control, and the private workshops have been organised under local committees and adapted to unaccustomed work of great precision. In Mr. Asquith words, "the history of the war in the industrial sphere at home has been a history of grave and threatening difficulties, courageously faced and successfully overcome." In spite of the withdrawal of men for the front and the employment of a million and a half of men and nearly half a million women on munition and war work, ordinary activities have been kept going without serious embarrassment. But when the war is over there lies ahead another strenuous time. There will be the cessation of war expenditure, the return of the men at the front with physical and mental capacity enlarged by the experience and discipline of service, and the disposal of the women who, in munition factories and elsewhere, have been replacing men and earning unaccustomed wages. Still, there is no reason for pessimism. Our productive output has been enormously increased under war stress, and may be maintained in peace. There has been the creation of very large new engineering factories, older factories have been overhauled and equipped with new high-class tools. Manufacturers have co-operated in a way unknown before, and workshop methods and organisations have been improved. Industry has been modernised and invigorated.

Certainly, relations between employers and employed have been unsatisfactory in the past. There are signs that the admirable co-operation which has been exhibited during the war has produced a better feeling. We may hope that with some increase in the rewards and improvements in the condition of workmen deliberate restriction of output may be abolished. Adopted partly from false economic ideas, partly from natural anxiety as to wages

and status as craftsmen, it has been, as Mr. Arthur Chamberlain says, effective, but at a terrible cost in loss of production.

*(Concluded.)*

## SOME HINTS ON SHAFTING ERECTION.

By F. R. Parsons.

### Erection and Alignment.

The erection and alignment of shafting is frequently undertaken in a far too slovenly and haphazard fashion, and the results obtained are generally in direct proportion to the degree of intelligent thought bestowed on the operation.

On one occasion the writer remembers an engineer giving instructions to a mechanic to erect a line of 2 in. shafting, 35 ft. long, to the side of an isolated, wooden structure, portably erected on a concrete floor, and built of uprights 4 in. by 2 in., spaced about 3 ft. apart, the interior just matchboarded. When it was tentatively suggested that the erection was insufficiently rigid to withstand the weight and running strains involved the engineer irritably repeated his instructions to get on with the job, and remarked with an air of finality that the brackets and shafting would *stay the building*.

### Happy-go-Lucky Methods.

Only just recently the writer happened to be visiting a works in which some considerable extensions to one of the departments were in progress; a line of 2½ in. diameter shafting being erected on cast-iron columns running down the centre of a shop on the second floor. The shop was about 150 ft. in length, 12 in. by 6 in. rolled-steel joists, spaced about 12 ft. apart, supporting the floor. The whole of the material—plummer blocks, brackets, shafting, pulleys, and clutches—with the exception of the columns, had been removed from another building, and rather than alter the disposition of the machines, and their respective pulley drives, the columns were being erected to meet the previous lay-out without any regard whatever to their position over the supporting joists. As a matter of fact, more than half of their number came somewhere near midway between the latter, and were merely bolted down to the 1 in. flooring and the 9 in. by 2 in. deals.

### Lack of Understanding.

The foregoing illustrations will serve to show the truth of the opening statement of this article, but if need be, other and equally as flagrant examples might be cited showing equally as lax methods to be in vogue. The writer's contention is that it is not so much the intent to scamp, or to take risks knowingly, that allows such schemes to be perpetuated, but a lack of intelligent understanding of the actual necessities involved in running shafting and power transmission.

Just as long as shafting will revolve without giving undue trouble in the matter of heated bearings or undue vibration, no thought whatever would appear to be bestowed upon the factor of friction, or what the shafting line absorbs in power to drive it. Many instances have come under the writer's notice where quite a quarter, and, in some cases a third, of the total power developed by the engine, or prime mover, has been absorbed in driving the shafting alone, and this before a single ounce of work is put upon it.

The factors conducive to economical power transmission may be considered under three headings, viz., shafting alignment, the disposition and character of the bearing surfaces, and balanced drives.

### Shafting Alignment.

Dealing first with shafting alignment, let us examine, as a preliminary, the character of the strains ordinarily involved under any condition. First, we have a torsional strain due to the power applied to rotate it; the second is a bending strain due to its own weight, the weight of the pulleys and the pull of the belts; the latter mainly affecting whatever amount of friction is set up by the character and disposition of the bearings.

The distance from bearing centre to bearing centre, though all too frequently a factor almost completely overlooked in erecting shafting, is one of far greater importance than is generally accepted by those even who profess to be well versed in these matters, that is if good running conditions are to be secured. This question of bearing centres is not one to be settled by mere guess work, or yet to be decided by whatever means are already existing for the convenience of bearing supports. But it is one for which a definite and safe rule exists, to depart from which to any great extent means courting trouble.

Such a rule may be found in the following:—

$$5\sqrt[3]{\text{shaft diameter squared}}$$

= distance in feet between the bearings of a shaft carrying an average number of pulleys, or an average weight of pulleys.

### A Few Examples.

The following table gives a few examples worked out from this formula applicable to shafting of from 1½ in. to 4 in. diameter:—

Table of Bearing Centres.

| Dia. of Shaft in Inches. | Distance C to C of Bearings. Ft. | In. |
|---|---|---|
| 1½ | 6 | 6 |
| 1¾ | 7 | 3 |
| 2 | 8 | 0 |
| 2¼ | 8 | 6 |
| 2½ | 9 | 3 |
| 2¾ | 9 | 9 |
| 3 | 10 | 3 |
| 3¼ | 11 | 0 |
| 3½ | 11 | 6 |
| 3¾ | 12 | 0 |
| 4 | 12 | 6 |

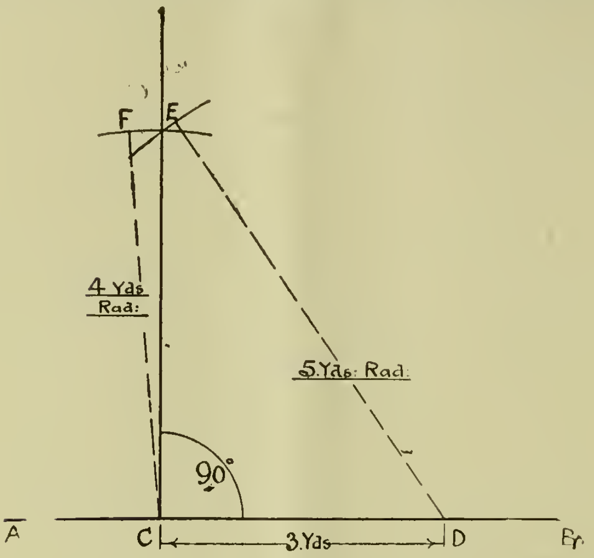
Upon the determination of bearing centres rests the amount of deflection to which shafting is subjected, hence the wider the bearing centres the greater the amount of deflection. Even with shafting erected, as per rule, and no pulley load on it, deflection must exist to some extent, but it need not be of such an amount as to interfere with good running conditions. A fair limit of deflection per foot of length between bearing centres would be 0·01 in. If beyond this the danger line is being encroached upon.

### Levelling-up Shafting.

This brings us to the question of levelling up shafting. The writer has on several occasions seen a mechanic trying to level up shafting by means of a spirit-level, perhaps no more than 6 in. or 9 in. in length, placed on the shaft at various points between two bearings. It must be obvious, in view of the deflection already mentioned, that it must be perfectly impossible to arrive at any correct results by adopting such methods, and no mechanic worthy of the name would be content to rely on this for accurate results. A straight-edge at least 6 ft. in length, longer if convenient, should be used in order that discrepancies due to deflection may be corrected.

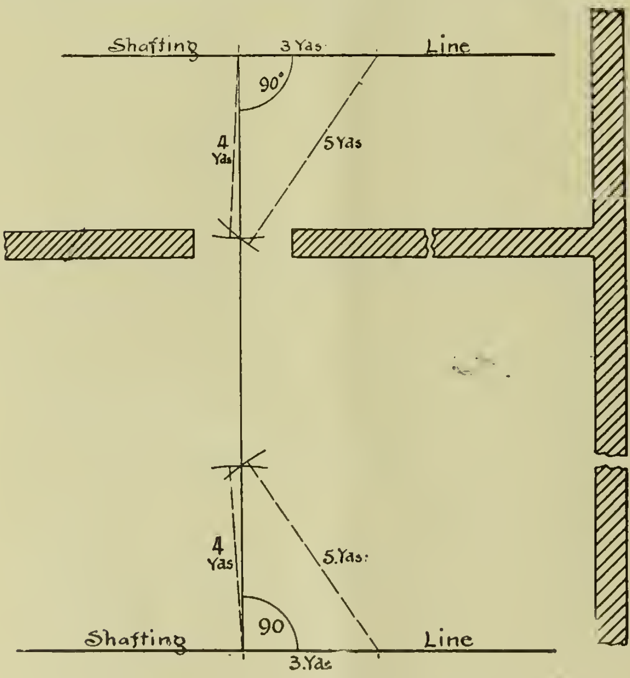
## Lateral Alignment.

Lateral alignment is generally less difficult to secure than vertical. When erecting new shafting, in which all couplings have been keyed, and the flanges faced after the operation of keying—is not this practice, however, decaying?—




Some Hints on Shafting Erection.—Fig. 1.

the drawing together of the several lengths will, if the bearings are allowed slack on their brackets, tend to automatically align and locate the shaft line laterally. In this connection, however, the writer has for many years been in the habit of adopting a method wherein he has used a fine steel line—piano-wire, I think, it is called—and



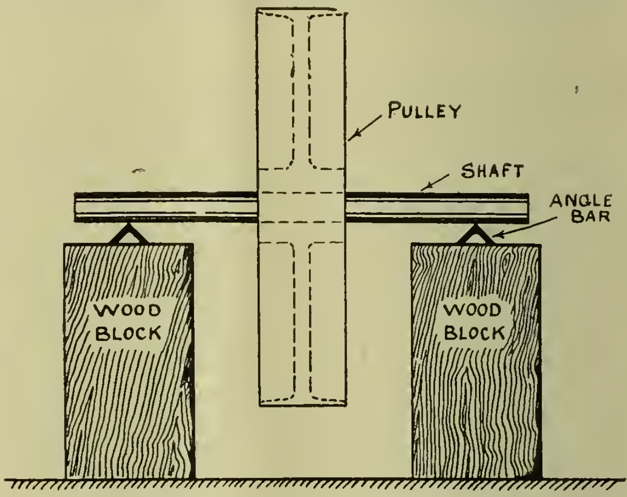

Some Hints on Shafting Erection.—Fig. 2.

a stretching-screw arrangement. This enables a much longer line of shafting to be aligned at one setting than can be accomplished by means of ordinary cord, since a much greater tension and less deflection of the line can be secured. As a matter of fact, a line of $2\frac{1}{2}$ in. diameter shafting, 125 yards in length, was on one occasion aligned and set by the writer by means of a single wire line stretched from the extreme outer brackets.

## Setting Out Right Angles.

Setting out right angles from a line of shafting is often a troublesome and perplexing process to a mechanic who possesses no notion whatever of geometrical laws or rules, and has nothing to assist him beyond, perhaps, a two-foot square. To trust to an ordinary length square in order to obtain a true angle, especially when the distance to be projected is great, is certainly courting trouble. A much safer way to lay out a square line is as follows. Let us assume that we desire to set out on the floor a right angle from an existing shafting line.

First of all, we should drop two plumb-lines from the shafting to the floor, and from these two points make a chalk line at least 6 yds. to 8 yds. in length, as at A, B, in Fig. 1. Now, at somewhere near the centre of this line set a point C, then from this with a steel tape, or ruled rod, make another point D exactly three yards distant on the line. Having these two fixed points, we now take a length of strong cord, or, better still, fine steel wire, attaching one




Some Hints on Shafting Erection.—Fig. 3.

end to a pointed nail, or scriber. Then carefully measure five yards along the wire, and at this point twist it around another nail, or similarly pointed instrument, and with the end held at the point D stretch the wire taut, so as to describe on the floor a short arc E near the position which the square line will take from the line A, B; this being shown in the illustration. Now shorten the length on the wire until the next measurement is exactly four yards from the end pointer, and bring the latter to the point C, and describe another short arc F so that this will intersect E. A new line now set out from this point of intersection to C will be an exact right angle to that of A, B, and can be extended any distance along the floor.

Fig. 2 shows the application of this method to an example where a perfectly parallel line is desired to be set out from another in an adjoining room or building, the only means of communication being a doorway.

## Pulley Balancing.

It is a very rare occurrence to find a pulley, whether of cast iron or steel, to be accurately in balance. When the shafting speed is excessive, or, we will say, anything above 350 revolutions per minute, half a dozen unbalanced pulleys on a line of shafting are apt to create a vast amount of un-

pleasant vibration, and perhaps give rise to bearing trouble. It is therefore time well spent when erecting high-speed shafting to check over each pulley for balance before putting it into work.

Quite an effective way of doing this, and one that involves no costly preparation in the matter of tackle, is to provide two short lengths of angle iron, say about three feet in length, and about 2 in. by 2 in. by $\frac{3}{8}$ in. in cross-section. Carefully straighten these, and with a file clean up the outside of the root, and remove all burrs or bruises formed thereon. Now get some blocks, or other suitable packing, of a height that is greater than half the diameter of the largest pulley it is intended to balance. Set these level on the floor, and lay the angle bars on the top of them, the roots upward, checking them carefully for parallelism and wind, and making sure that they are level both singly and together, longitudinally and transversely. The sketch given at Fig. 3 should make this arrangement clear. Now mount the pulley to be checked upon a well-fitting, parallel mandrel, or short piece of shaft, of such a length as will span the angle bars, allowing 2 in. or 3 in. overhang at either end. Place the whole in the centre of the bars, and note if there is a tendency for the shaft and pulley to roll. If such is the case the pulley is out of balance, and in the event of the pulley rolling along the bars a certain distance and then coming to rest such indications will prove that the pulley is light at the top, and requires a weight attached to it in order to equal in weight the lower side of the pulley.

## FUEL ECONOMY ON THE NORTH-EAST COAST AS A RESULT OF ELECTRIC POWER SUPPLY.*

By R. P. Sloan.

Electric power supply, though of comparatively recent development, has already had a marked effect upon the industries of the North-East Coast, for example:—

1. A great saving of coal and reduction of smoke has resulted. There is now, apart from the power companies, practically speaking, no coal burned on the Tyne for power purposes, except by the railways and chemical factories and some collieries. The Tyne shipyards and engineering works may be said to have adopted electricity to the exclusion of all other forms of motive power.

2. The application of electricity to all new uses has been facilitated:—

(*a*) Many collieries depend entirely upon electricity supplied from the Newcastle and Durham electric power companies' combined system for all their power requirements.

(*b*) As a result of the adoption of electric traction, the suburban railway traffic facilities of Newcastle are more ample than those of any other town of similar size.

(*c*) Electricity has been applied to freight haulage on the Newport-Shildon line (and this is the first real example of heavy freight haulage by electric locomotives in this country).

(*d*) Electricity has been applied with particular success to drive rolling mills and colliery winders, and for other purposes requiring the concentration of a large amount of power on one shaft.

3. New industries have been established in the district purely because of the cheap power available.

4. Extensive utilisation has been made of the waste heat and gases existing in the area for the production of electrical energy. In this regard the district occupies a unique position owing to the extent to which its power requirements have been met by electricity produced as a by-product of two of its largest industries—the making of pig iron and the making of coke.

5. Several small, and therefore uneconomical, generating stations—municipal and company—have been shut down, and the electrical distribution systems which they supplied have been connected up to the power supply companies' system.

The problem of power supply in any district is so completely governed by local conditions that it may be permitted at the outset to summarise the nature and extent of the staple industries of the North-East Coast. The table above does this in convenient form.

It will be seen that in coal, iron and shipbuilding the North-East Coast figures represent respectively and approximately one-fifth, one-third, and one-half of the nation's output. It was early realised that the more completely the electrical wants of the whole community could be met, the more cheaply could a supply of electricity be given and the more stable would the electric supply industry become. Our engineers therefore proceeded to design the system so as to be capable of producing current at a minimum cost and of providing a satisfactory supply for all purposes—power, traction, lighting, and electro-chemical and similar processes.

The extent of the area (1,400 square miles) necessitated the generation of electricity at a pressure and in a form facilitating transmission over long distances, while the nature of the market to be catered for made it essential that the current should be produced as cheaply as possible. This, in turn, involved the use of extensive sites with ample coal and water facilities for the main coal-fired power stations, which were erected to deal which such portions of the load as could not be supplied with electrical energy generated by waste heat. From the two main stations situated on the River Tyne the transmission and distribution networks extend into and through the city of Newcastle-upon-Tyne, northwards to Blyth and beyond, and eastwards along the River Tyne, through Wallsend to North Shields. On the south bank of the Tyne the system extends southwards through

* Paper read before joint meetings of Sections B and G of the British Association at Newcastle, Sept. 8th, 1916.

North-East Coast Industries.

| | Population at Census, 1911. | Coal Mined, 1913. | Coke Made, 1913. | Ironstone Mined, 1913. | Pig Iron Made, 1913. | Merchant Shipping Built, 1913. |
|---|---|---|---|---|---|---|
| | | Tons. | Tons. | Tons. | Tons. | Net Tonnage. |
| North-East Coast industrial area ... | 2,300,000 | 56,352,218 | 7,500 000 | 6,010,836 | 3,869,214 | 625,289 |
| United Kingdom... | 45,211,888 | 287,430,473 | 20,529,732 | 15,997,[illegible]28 | 10,260,315 | 1,231,921 |
| Ratio— | | | | | | |
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| North-East Coast / United Kingdom ... | 5·1 | 19·6 | 36·5 | 37·5 | 37·7 | 51·0 |

the county of Durham from the coast to Consett and Bishop Auckland on the west, and then joins up with the system of the Cleveland and Durham Electric Power Co., whose area covers the South Durham and Yorkshire districts, including the Cleveland mining districts, Stockton-on-Tees, Middlesbrough, etc. The distance between the northern and southern extremities of the transmission system is 70 miles, and it is now possible to obtain electricity on the same system as regards frequency and voltage throughout practically the whole of the area embraced in the scheme. The main transmistions in the United Kingdom, but as the North-East Coast a frequency of 40 cycles per second, and the working pressure is 20,000 volts.

The capacity of plant installed represents about one-ninth of the total plant installed in public supply station in the United Kingdom, but as the North-East Coast power companies are working at a more constant load—*i.e.*, a better "load factor"—the electricity actually generated is about one-fifth. The total horse power at present being supplied is 343,000 H.P.

Though the extension of the power supply system has been rapid, its development and the growth of its profit-earning capacity were considerably delayed by the work which had to be done from time to time, and the sacrifices that had to be made, to secure uniformity of system. Unfortunately with each amalgamation, or extension of area, considerable alterations had to be effected in the system of the new undertaking concerned. For example, the system of the Newcastle-upon-Tyne Electric Supply Co.—the pioneer company—the first instalment of which was laid down in 1899, is a 3-phase 40-cycle system. That of the Durham Collieries Electric Power Co., the operation of which the Newcastle-upon-Tyne Electric Supply Co. took over in 1907, was a 50-cycle 3-phase system, while the Tees area of the Cleveland and Durham Electric Power Co., where supply was begun in January, 1906, was originally designed for 25 cycles. The same company's Consett and Bishop Auckland stations were designed, one to give 3-phase 25-cycle current, the other 2-phase 50-cycle current. It will be appreciated that these alterations (involving in some cases the complete redesign of system) have necessarily delayed development, but it was considered best to secure uniformity, even at some sacrifice of time and money. All these other systems were sanctioned and commenced some time after the original Newcastle system was laid down.

The work of making the systems uniform has been completed, and, in addition, several small and therefore uneconomical generating stations have been shut down. Throughout the area embraced in the scheme there are now only three public supply stations not conforming to the standard system and frequency, viz., those of the Sunderland, South Shields, and Darlington Corporations.

The local conditions governing power supply in the district are:—(1) The low price of coal, which would enable the manufacturers to produce power themselves at relatively low rates. (2) The fact that the manufacturers' works are mostly of considerable size, *i.e.*, their individual electrical requirements are large. (A factor invariably of vital importance in the production of cheap current, whether by a public company or a municipality or by a private manufacturer, is the capital expenditure per useful horse power of plant. This decreases as the size of plant grows, while the running efficiency at the same time increases.) (3) The existence of large quantities of potential energy in the form of waste heat and combustible gas.

The first and second conditions have been met by the power companies, in erecting their main generating stations:—(*a*) By taking full advantage of the best coal and water facilities available; (*b*) by installing plant of a capacity much in excess of that which any individual manufacturer, however large, could adopt; (*c*) by catering for all classes of consumers, thereby securing a diversity of load with a resulting constancy of output and so utilising the plant installed to the best possible advantage. These factors, combined with the employment of a highly-skilled technical staff and attention to numberless relatively minor details, have resulted in securing an efficiency of production much greater than that practicable to any manufacturer producing power merely as an auxiliary to his main business. This is, after all, an age of specialisation, and the production of electricity from coal at a minimum of cost presents opportunities for the highest technical skill and for unremitting vigilance.

Power supply in this district began on the north bank of the Tyne. It is natural, therefore, that its highest development was reached there earlier than in other parts of the district. By 1908 it could be said that there was not a single firm of shipbuilders or engineers on the north bank of the Tyne which did not take 95 per cent of its power from the company. To-day the proportion is probably higher still. Even taking the whole area, it may now be said that, as regards the engineering trades as distinct from collieries and iron and steel works, from 75 to 80 per cent of the power is supplied from the power companies' system.

(*To be continued.*)

## INCREASING USE OF PIPES AND TUBES.

Nowadays the uses of metal pipe are numbered by the thousands. Among such uses may be mentioned agricultural implements, automobile parts, bedstead and hospital furniture, architectural ironwork, grill work, etc.; building columns, refrigerating machinery, dry-kiln apparatus, elevator cars, fence posts, flag poles, wheelbarrows, elevator grain spouts, irrigation systems, safety ladders, loom cylinders, warship masts, lighting and high-tension poles; electric wiring conduits, speaking tubes, lunch counter stools, signal towers, etc.

Coincident with the extended use of tubular products, states the National Tube Co. of Pittsburgh, has been not only greatly-increased tonnage, but also a change in material. Fifty years ago, it is stated, practically all of the screw-joint pipe was made from wrought iron, but the invention of the Bessemer and the open-hearth processes of making steel have caused a decided change in the material. A special statistical bulletin issued by the American Iron and Steel Institute of New York shows that the production of iron skelp decreased from 452,797 tons in 1905 to 262,198 tons in 1915, while the steel skelp production increased from 1,039,198 tons in 1905 to 2,037,266 tons in 1915, or an 88·6 per cent increase compared with the decline of 11·4 per cent in the iron skelp production during the same period.

The history of the widely-ramifying uses of pipe reads almost like a romance, and inasmuch as the National Tube Co. has recently announced plans for building a new plant at Gary, Ind., having a capacity of 500,000 tons per year, it would appear that the uses of metal pipe have by no means reached their limit.

## ROCK ASPHALTE: ITS INDUSTRIAL APPLICATIONS.

By James Vose.

The functions of industrial engineers often include amongst those of the more directly mechanical engineering character that of the general upkeep of the building fabric. Some information as to the most recent applications of rock asphalte will probably be of interest to many readers. Some of them will be curious as to what the material really is and how it is prepared for use.

### What Rock Asphalte Is: How Prepared for Use.

Summarised, rock asphalte virtually is a fusible rock, which can be melted or softened, cooked, spread on any rigid foundation, as wood, concrete, brick, flags, etc., and, on cooling, again becomes a resilient rock. In fact, some enthusiastic users have christened it as a "mineral rubber." Rock asphalte is quarried or mined in Germany, France, and Italy chiefly, and also is largely manufactured synthetically in this country.

### The Natural Product.

As regards the natural product, it is composed of limestone, more or less impregnated with a high-grade natural pitch or bitumen. Commercially, it is mostly used in the form of "mastic" asphalte, which is made by grinding the rock to fine powder and cooking in large cauldrons for several hours, it being mechanically stirred during the process and Trinidad refined bitumen added to make up the total content of bitumen to about 15 per cent. It then is drawn from the cauldrons and poured into moulds forming round, hexagon, etc., blocks, each weighing about ½ cwt.

### Synthetic Asphalte.

When made synthetically, limestone, which is not naturally impregnated with bitumen, is ground to powder and mixed with the full 15 per cent of Trinidad bitumen in the same class of cauldron as before mentioned. The Trinidad bitumen so used is practically the same in chemical composition as that found in the natural rock.

### Preparing and Using Asphalte.

When required for use it is prepared by breaking up the blocks of mastic asphalte and melting and cooking in iron cauldrons, the most-used sizes of which hold about 8 cwts. It is cooked for several hours, being well stirred until it drops easily from the stirrer, which is manipulated by hand. On certain large jobs mechanically worked cauldrons are used. The asphalte then is taken from the cauldrons in buckets and placed on the floor or roof and spread to proper thickness with a wooden trowel. For covering vertical surfaces the asphalte has to be spread in small quantities in the manner of plastering. The usual thickness for floor or roof work is 1 in., for flat, damp courses ½ in., and for vertical work ¾ in. On roofs and walls the rock asphalte is laid in two separate coats with fused overlapping joints. A skirting of asphalte usually is advisable, and an angle fillet of the same materal at the junction of the flat and vertical asphalte. In the case of floor work the asphalte is laid in a single coat, and during the cooking process now mostly is "armoured" by incorporating from 20 per cent upwards of clean granite chippings. This adds to the wear-resisting properties of the asphalte and also cheapens the cost of the job somewhat. A little Trinidad asphalte is added as a flux when cooking the asphalte.

### Characteristics and Industrial Uses.

The characteristics of rock asphalte which specially recommend it to industrial engineers include extreme durability under foot, trolley, or vehicular traffic, watertightness, noiselessness, dustlessness, jointlessness, fire reistance, and a considerable degree of heat and electrical current insulating capacity. Its slight resiliency and its homogeneousness is largely responsible for its long life under traffic, and its other characteristics add to its general serviceabilty in this connection. The fact that rock asphalte can successfully and quickly be laid on wood, and that it is watertight, is often of great service in the rearrangement of departments, as a wet process then can be carried on if desirable on an existing upper wood floor. Worn wood floors, too, can quickly be given a smooth wear-resisting surface. This has proved useful in the present war conditions. For instance, several old mill floors were quickly thus made available as a canteen for female munition workers at Messrs. Greenwood and Batley's Leeds works, a dustless surface, which can be flushed with water if need be, soon being produced. In another recent example, the covering of tracks on the worn floors of a flour mill resulted in the loading of the firm's motor wagons with sacks of flour being expedited by an hour or two each day, due to the ease with which the trolley traffic then was conducted. This latter feature is of increased importance now that female labour is more extensively being employed.

### Repairing Flagged and Concrete Floors.

One of the applications of rock asphalte which will most directly appeal to *Industrial Engineer* readers is the repairing of worn or broken concrete or flagged floors H.M. Inspectors of Factories have for some years back noted that many accidents to workpeople have been caused by these defects, not to speak of the decided hindrances to production and direct money losses due to this cause. It long has been recognised that the joints of flagged floors always are the vulnerable points, and in the case of concrete floors the constant turning of trolley wheels at any given spot rapidly scoops out holes in the floor.

We are indebted to Messrs. John Dickinson and Co. (Bolton) Ltd., of Fairclough Street, Bolton—who have considerable experience in the construction, reinstatement, and repair of works floors—for the following sketches and details of how such defective floors can efficiently be repaired by the use of rock asphalte. It will readily be appreciated by practical men that each square foot of such repairs often will put six or seven times that area of floor into good useable condition, as, just in the same way as the strength of a chain is that of its weakest link, so is the working condition of a floor to be judged by its most defective portions.

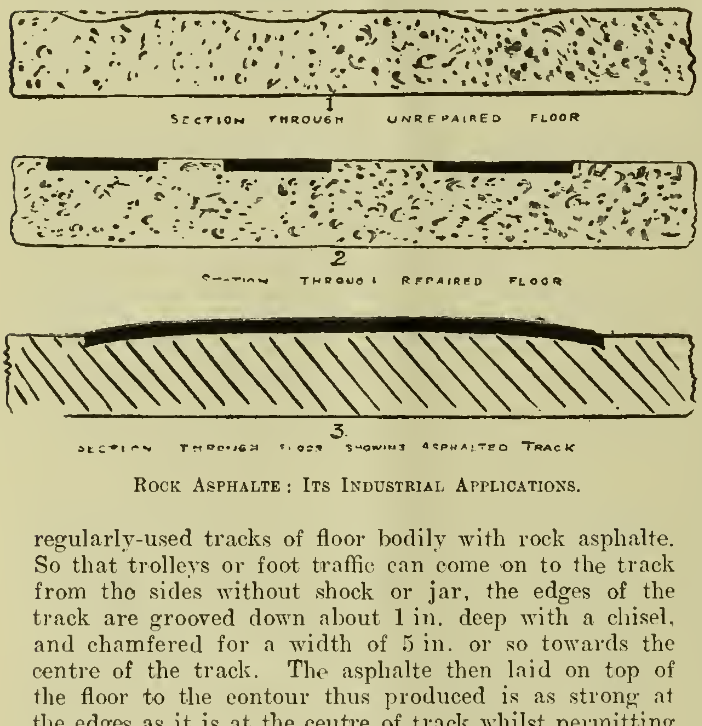
It is found that these repairs often must be done in comparatively small amounts at a time, at week-ends, evenings, or other odd times, so that in many cases it is best for the handy men of industrial concerns to do the work themselves rather than the specialist firms, who naturally cannot deal with less than a certain minimum of work at a time if the job has to be executed at a mutually reasonable price. Consequently, Messrs. Dickinson have evolved a system of supplying sufficient material to do about 60 square feet of such patchlike repairs, and this parcel, which costs about 38s. f.o.r.

Bolton, has proved very useful to firms at home and abroad, who thus can execute minor repairs and judge as to the advisabilty of having floors or tracks covered bodily when circumstances render such desirable.

### Working Instructions for Floor Repairing.

It is necessary first to square down the edges of the worn or broken places with a chisel, and the portions of floor thus outlined are recessed about 1 in. deep—the usual thickness for rock asphalte for floor work. The cooked asphalte then is poured into the recesses and spread level with the rest of the floor with a wooden trowel. The asphalte may be walked on in two or three hours after being laid. It is prepared by being broken into rather small pieces with a sledge hammer and melted and cooked with a little Trinidad bitumen in any improvised iron pan, and kept well stirred until it drops easily from the stirrer. We have seen a big lead melting pot, a domestic washing copper set in brickwork, or even a large bucket used on occasion as a pan. When the asphalte is cooked, from 20 per cent upwards of dry granite chippings—from ⅛ in. to ¼ in. gauge—are thoroughly incorporated. This, of course, makes the asphalte cover a correspondingly larger area of floor and cheapens the total cost.

Sometimes it is advisable to cover certain well-defined,




Rock Asphalte: Its Industrial Applications.

regularly-used tracks of floor bodily with rock asphalte. So that trolleys or foot traffic can come on to the track from the sides without shock or jar, the edges of the track are grooved down about 1 in. deep with a chisel, and chamfered for a width of 5 in. or so towards the centre of the track. The asphalte then laid on top of the floor to the contour thus produced is as strong at the edges as it is at the centre of track whilst permitting traffic to enter from the sides without shock or jar.

Usually, when such tracks, or whole floors, are to be covered it is best to have the work done by experienced men, using the cauldrons specially designed for cooking asphalte.

The accompanying illustrations, for the use of which also we are indebted to Messrs. Dickinson, show in Fig. 1 a section through a worn floor; Fig. 2 shows the same floor repaired with asphalte by the method just described, and Fig. 3 a track covered as just mentioned.

In a subsequent article we propose giving some details as to the repair of stone or wood steps, hoist landings, etc., and the lining of variously constructed tanks with special acid-resisting asphalte.

## STEAM-PLANT EFFICIENCY.*

By Vernon Smith.

The aim and object of every engineer is to produce power cheaply, which means that he must not only have the most modern type of machinery, but he must also maintain this machinery to give a maximum efficiency. The engineer of to-day is a man who can understand and appreciate both figures and facts, and who can also calculate what every part of his plant should do. To minimise the labour this involves, many forms of recorders and registering machines have been evolved which, in many instances, are admirable, and fulfil to a degree all that is claimed these machines will do; but there are many things which are dependent upon the personal supervision of the engineer, and the failure to do so often means inefficiency. It is with this knowledge that I have dealt with the following points.

*Lancashire and Cornish Boilers.*—The present period is a most critical one for the Lancashire boiler, and the next few years will decide whether or not it shall retain the position it holds to-day, or whether it shall serve only as a milestone in engineering progress.

At no previous date has the cost of producing power been so seriously considered as it is to-day. Recorders are fitted to many parts of the plant, so that the engineer can observe at any moment what the plant is doing, and efficiency tests are run very frequently. It is the outcome of this tendency of running efficiency tests that threatens the existence of the Lancashire boiler, coupled with the energies of the makers of water-tube boilers, and who have used arguments against Lancashire boilers in favour of water-tube boilers which I doubt very much they can sustain. To be set off again whatever efficiency advantage the water-tube boiler may have overt he Lancashire boiler is the etxra cost of maintenance and the increased working costs. More skilful attendants are required for the former than for the latter, and for cleaning and repairing more skilful engineers are required, therefore the running costs are more, and as the general rule regarding water-tube boilers is one of conveting them into high-speed evaporators, the maintenance costs will naturally increase.

Many kinds of water-tube boilers require the tubes to be bored out so often, even in moderately poor water, that they should have the expense of this charged to repairs. The behaviour of water-tube boilers when using bad water is extremely serious from an economical standpoint, for even large tubes fill up or become thickly coated with incrustation in a comparatively short time. It is even admitted by some makers that their boilers would be useless if they had not been able to devise a machine for boring bent tubes, for the tubes would not only be lined with deposit, but would become completely choked, and have often been found so.

Where large units are desirable, and where ground space is of consequence, the water-tube boiler is undoubtedly the proper type of boiler to install; but apart from this there does not appear to be very much to recommend it or justify the claims that are made on its behalf—that it is a better and more efficient boiler than the Lancashire—unless it be that steam can be raised quicker with a water-tube boiler when being set to work after cleaning than with a Lancashire boiler. Comparing the efficiency of an ordinary hand-fired Lancashire boiler with that of a water-tube boiler working under similar conditions, the former will un-

* From a paper presented before the South Wales Institute of Engineers.

doubtedly be found to be less than the latter; but if the two plants are equipped with suitable accessories the efficiencies will be found to coincide, or nearly so.

There are two serious impediments regarding the Lancashire boiler, as it is generally worked to-day, which seriously affect its efficiency. The first point requiring consideration is the design of the furnace. It is very essential, if the furnace is to be efficient, that the temperature should be as high as possible and in a manner act as a reverberatory furnace; but this means that the combustion chamber should be fairly large and built with the best quality firebricks. Temperature alone is not only required to complete combustion, but time is also necessary, hence the large combustion chamber should be fairly large and biult with the best quality firebricks. Temperature alone is not only required to complete combustion, but time is also necessary, hence the large combustion chamber.

Experiments haveb een made and proved successful, so far as improving the efficiency of a Lancashire boiler is concerned, by lining the flue of the boiler or furnace with firebricks, but the temperature was so high that the arches continually fell in. When the gases pass from the grate of a Lancashire boiler they immediately impigne on a comparatively cold plate instead of being suspended for a short time in a combustion chamber having a temperature of, say, 2,500 deg. Fah. The cold furnace plates immediately reduce the temperature of the gases and allow the unburnt carbon to pass off as soot. This is found to be the case more so where cross-tubes are fitted in the boiler flues, the reason for this being that the gases passing along the flue have a core of green smoke which is very difficult to burn, and when it first ignites it is not very difficult to put out the flame; the cross-tubes, which are fairly cold, check the small flames from igniting the green smoke.

Too much attention has been paid to the back end of Lancashire boilers at the expense of the furnace. A reduction in temperature of the flue gases at the flue exit appears to bet he chief aim, and, to achieve this, economisers, air-heaters, and superheaters have been installed. When the gases prior to entering the chimney have been reduced to about 250 deg. Fah., it has been considered to be giving its maximum efficiency; but this is not the case, and can never be considered as such, so long as the old-fashioned furnace is adopted, and which can be considered, to a degree, to act as a condenser.

A hand-fired furnace of any description is undesirable, as every time the furnace is fired the flues are drenched with cold air, and this drenching is far more disastrous when the bars are cleaned. Whenever they are fitted the flames should not be allowed to play on the cold plates of the boiler flues, but should first pass through a chamber constructed of firebricks. Of course, difficulties will be experienced when cleaning the boilers; also, this baffling will call for a stronger draught.

Increasing the velocity of the gases passing over the heating surface of an ytype of boiler considerably increases the evaporative capacity without affecting seriously its efficiency, as, approximately, the rate of evaporation in pounds per hour per square foot of total heating surface (boiler and economiser) increases directly as the speed of the gases, being equal in pounds per square per hour to from one-eighth to one-tenth of that speed in feet per second. Thus, with a gas speed of 30 ft. per second (the present-day practice in hand boilers) the evaporation is 3 lbs. to 4 lbs. per square foot of heating surface, whilst with 100 ft. per second the evaporation is 11 lbs. to 12 lbs. per square foot per hour.

Various claims have been made by advocates of live steam feed-water heaters, varying from 5 per cent to as muc has 12 per cent efficiency increase, and whilst I am not in total agreement with the claimants of 12 per cent efficiency, I certainly agree that these heaters do contribute to an increase of officiency. Their justification for inclusion in steam plants is not this consideration only. They increase the evaporative capacity of the boiler, and tend to minimise the strains in the case of Lancashire boilers, owing to the large body of water this type of boiler carries. Considerably more heat per square foot of heating surface per hour is absorbed by water at the bottom of a Lancashire boiler at a temperature of 300 deg. Fah. compared with water at a temperature of, say, 100 deg. Fah.

Before leaving this side of the subject it will no doubt be of interest to look into and discuss further the question of "dish ends" for Lancashire and Cornish boilers. The prejudice and disfavour which followed immediately upon the introduction of this unconventional method of boiler making in England has almost disappeared, as each year witnesses a great tendency on the part of engineers to install this type of end for these boilers. All sorts of theories were put forward when "dish-end" boilers were first introduced, such as "inflexibility," "excessive strain on flues," "grooving at the corners," etc., none of which has been sustained with the exception of the former, and this, in the opinion of the author, is a virtue rather than a vice. A "dish end" is supposed to be part of a sphere, and as a sphere is the natural form, and therefore the strongest to withstand internal pressure, inflexibility, or the inability of the end plate to deflect under pressure, is a natural result; but as corrosion and cracking of plates are usually greatest at these points where breaking takes place, it is to the advantage of the end plate that this be as rigid as possible, and the author's opinion is that these plates should be made absolutely rigid. Radii between 10 ft. and 10 ft. 6 in. should form the standard for large boilers, and the thickness should be determined accordingly.

The question might be raised here concerning the stresses caused by the elongation of the flues which would appear to take place with "dish ends," but which are partly obsorbed by deflection in the case of "flat ends." The trouble arising from the latter is manifested in the very common trouble of leaky toe rivets in the stays and cracked end plates. The stresses set up in the flues of a boiler are incalculable, and any attempt to calculate these stresses can only give approximate results, the reason for this being the varying temperatures at different parts of the flues, due to the water in the boiler. The temperature of the plate at the top will be much higher than that at the bottom. This is also the case with the boiler shell, and it is for this reason that these boilers should not be forced when raising steam after cleaning, as some parts of the plate are in tension whilst other parts of the same plates are in compression; hence the leaky joints and cracked seams.

It is, of course, generally known that the flues of a boiler elongate as steam is raised, also that the elongation is partly absorbed by the Adamson joints, and in the case of the "flat-end" boiler part is taken up by the deflection of the end plates; but there is no reason why the whole of the elongation should not be taken up by the flue. This can very easily be arranged for by inserting a corrugated section about 10 ft. long, or, better still, have the whole of the flue corrugated; this will reduce to a minimum the deflection at any point, and incidentally increase the heating surface of the boiler at a most beneficial point. The difficulty of withdrawing the ashes can be overcome by covering the flues immediately below the firebars with a

sheet-steel apron. Where only a section of a flue of a boiler is corrugated, it is a good rule to follow to make the length of this section not less than 25 per cent of the total length of the flue, as this is equal to doubling the number of Adamson joints, and, in consequence, reduces the stress on the flues and end plates.

*(To be continued.)*

## PRIMING IN STEAM BOILERS

By Edward Ingham, A.M.I.Mech.E.

### Priming.

It is common knowledge that the steam delivered from a boiler is never quite dry; no matter what may be the type of the boiler, there is always present in the steam a certain quantity of moisture in suspension.

During the process of evaporation in the boiler, the steam bubbles, as they rise through the water, tend to lift up small particles of water with them. Some of these particles get carried along with the steam from the boiler to the engines, which are liable to suffer damage or even breakdown should the water not be effectively got rid of.

### Foaming.

The above action is known as "priming," and should, strictly speaking, be distinguished from what is known as "foaming," although the two terms are commonly taken to mean one and the same thing. When a boiler simply foams, the water particles are lifted up by the steam bubbles only a short distance above the level of the water in the boiler, but they are not carried out of the boiler; in other words, they do not become entrained in the current of steam passing through the junction valve, and consequently no serious consequences are liable to ensue. In short, the water simply froths and foams at the surface.

### The Dangers from Priming.

In the case of priming, since the water is carried over to the engines, it is liable to accumulate in the engine cylinders (unless continually discharged through the relief valves, etc.), and there is then danger of the water being driven violently against the cylinder ends by the moving piston, in which case severe knocking or even fracture of the cylinder ends may result. Where turbines are installed, the water will cause excessive friction, and may even result in blade-stripping.

Apart from the danger of breakdown to which it may give rise, priming is objectionable for other reasons. If it occurs to any serious extent, considerable loss of economy will result, a large quantity of the feed water never being evaporated into steam to do useful work in the engine cylinders. Another objection is that, in serious cases, the readings of the water gauges may prove to be unreliable, and a certain amount of risk of shortness of water, followed by overheating and collapse of the furnace crowns, is thus incurred.

Again, when a boiler primes badly, the indicator diagrams from the engine cylinders may be affected, in some cases to a considerable extent. The general effect seems to be either to increase the back pressure or to reduce the admission pressure, or to give a less indicator diagram than that which would be obtained if there were no priming.

### Causes of Priming.

Priming may be due to quite a number of distinct causes, which will be referred to presently. It is more liable to occur in boilers having small water surface areas and steam spaces than in those where the water surfaces and steam spaces are large. It is, for example, generally recognised that water-tube and vertical boilers as a rule give more trouble from priming than do large cylindrical boilers of the Lancashire and similar types. Amongst the more common causes of priming may be mentioned (1) the use of an impure feed water, (2) insufficient boiler power, (3) unsatisfactory design, (4) sudden opening of the junction or stop valves, (5) sudden demands for steam. As regards (1), this is perhaps the most common cause of priming. Waters containing the flour-like carbonates of lime and magnesia and large quantities of sodium chloride (common salt) in solution are those most liable to cause trouble. The carbonates have the effect of thickening the water, so that the steam bubbles cannot rise freely through it, and thus there is a tendency for small bodies of water to be lifted up and carried along with the steam. The presence of a small quantity of grease in the boiler accentuates the trouble.

In land practice, it is not often that salt water is used for feeding the boilers, but in some instances the feed supply is taken from a well near a tidal estuary, and the water may then be heavily charged with salt.

In many cases large quantities of soda are added to the feed water with the object of neutralising acids and causing precipitation of certain salts in solution, which would otherwise form scale on the plates and tubes, and this is undoubtedly a common cause of priming.

When there is insufficient boiler power it becomes necessary to force the boilers in order to provide the necessary steam. The general effect of this is, of course, to cause the steam bubbles to rise through the water more quickly than they would do under normal conditions of working, and the more the fires are forced, the greater will be the tendency for priming to occur. Whether or not trouble will occur by forcing a boiler will naturally depend on other factors, and under favourable conditions, considerable forcing may not give rise to the trouble.

### The Effect of Water Areas and Steam Spaces.

Much depends on the design of a boiler. As already explained, boilers with small water surface areas and steam spaces are far more liable to prime than those with large surface areas and steam spaces. The quantity of steam which can escape from a given surface without carrying water with it will, of course, be greater the greater the purity of the water. In some water-tube boilers, screen and separator plates of various types are fitted in the steam space, and these have the effect of increasing, artificially, the otherwise restricted water-surface areas.

### Bad Tubular Arrangements.

In boilers containing many small tubes, the latter are sometimes badly arranged, with the result that trouble from priming is more liable to occur than would otherwise be the case. Frequently the tubes are spaced too close together with the object of obtaining a large amount of heating surface, but this may result in defective circulation. Again, too many tubes may be put into the boiler, with the result that it is necessary to work with a high water level and consequently a restricted steam space. The obvious remedy here is to remove the top row of tubes if this be practicable.

### The Sudden Opening of Stop Valves.

With regard to priming caused by sudden opening of the junction or stop valves, the sudden opening means a

momentary local lowering of the pressure near the junction valve opening, and there is consequently a tendency for some of the water in the boiler to rush towards the opening and so mix with the steam passing out through the junction valve.

Sudden and heavy demands for steam will have a tendency to cause priming, because they necessitate hard firing for the time being and result in a reduction in the steam pressure and consequently increased agitation on the surface of the water, particularly in the case of small boilers. A boiler will often give no trouble from priming so long as the engine it supplies with steam works on its normal load, but immediately a temporary heavy load comes on considerable priming takes place.

### The Size of the Boiler.

The size of the boiler in relation to the amount of steam it has to supply to the engine each stroke is an important factor. If the quantity of steam taken by the engine per stroke is a comparatively large proportion of the steam in the boiler, the pressure will fluctuate considerably each stroke of the engine, and whenever this occurs, there is a tendency for priming to occur. When trouble occurs from this cause, it may be prevented, or at least reduced, by throttling down the steam supply at the stop valve, since this reduces the amount of fluctuation of the pressure. Sudden demands for steam are especially liable to occur at electric generating stations (where a number of engines or turbines may have to be started up all together), and at dyeworks, rolling mills, etc.

### Means for Preventing Priming.

As to the means for preventing priming, these depend on the design of the boiler, the conditions of working, etc. In most cases, some benefit will result by working with the water low in the glass, because the steam space is thereby increased. With horizontal cylindrical boilers, working with a low water level also means increasing the water surface area and consequently still further reducing the tendency to prime. When the trouble is due to the presence of impurities in the water, the remedy is obvious, viz., remove the impurities or, at least, some of them. This, however, is more easily said than done, and in many cases is not practicable. The opening of the scum cocks to remove scum and dirt from the surface of the water will often minimise the trouble. Temporary measures to prevent priming consist of lowering the dampers so as to check the fires until the water becomes quieter, and partially closing the stop valves so as to check the outrush of steam and water. If the water is seen to fall in the glass, the feed supply may be increased with advantage. In order to prevent damage to the engines, the cylinder drain cocks may be opened to help to get rid of the water in the cylinders, since the relief valves may be unable to cope with the excessive quantities of water carried over from the boilers.

### Reducing the Effects of Priming.

Many devices are fitted nowadays to steam boilers with the object of reducing the effects of priming. For instance, anti-priming pipes and baffle-plates are fitted inside the boilers, whilst water separators are fitted in the range of steam pipes between the boilers and the engines, near the engines. These devices are certainly of great use, but they cannot be relied upon to prevent trouble altogether in the case of heavy priming. In some instances priming has been prevented by enlarging the steam pipes near the boiler, *i.e.*, by making the pipe bottle-shaped just near the junction valve. By so doing, it would appear that the rate of flow of the steam in the enlarged portion of the pipe was reduced to such an extent that the water carried along with the steam was allowed sufficient time to enable it to fall back into the boiler.

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# New Companies Registered.

DRAKE AERONAUTICAL ENGINEERING SYNDICATE LTD. (145,094).—Private company. Registered October 17th. Capital, £3,000, £1 shares. Manufacturers of and dealers in toys, aeroplanes, hydroplanes airships, and other kinds of aircraft, makers, designers, importers and exporters of models, etc. Directors: C. R. S. Cadell, A. Coote, R. R. Drake, and J. Ward. Qualification, £1. Solicitors: Munby and Sparkes, Crosby Buildings, Crosby Square, E.C.

SOUTHEY GAS PRODUCERS LTD (145,121).—Private company. Registered October 19th. Capital, £30,000, £1 shares. To take over the business of Producers Ltd., and Producers British Rights Ltd., and the interest of Commercial Cars Ltd., in the benefit of certain inventions relating to liquid fuel gas producers, and any patents or inventions relating to producers of gas from liquid fuel, or to carburetters, etc. Directors: H. C. B. Underdown, J.P., Capt. the Hon. Wilfred C. W. Egerton and J. T. Burney. Qualification, £250. Remuneration, £250 each per annum (chairman £100 extra). Solicitors: Kimbers and Boatman, 79, Lombard Street, E.C.

TURBARITE SYNDICATE LTD. (145,141).—Private company. Registered October 23rd. Capital, £15, in 300 shares of 1s. each. To acquire patents, inventions, and concessions relating to the utilisation, by distillation, maceration, or other physical, chemical, or other means, of peat, wood, refuse, coal, cannel, shale, asphalt, or other carbonaceous material, etc. Agreement with W. L. St. J. Prioleau, J. R. H. Prioleau, and J. W. Johnston. The subscribers are: E. M. Bonn, 11, Stafford Mansions Palace Street, S.W., solicitor, one share; G. L. Devisse, 118, Chesterfield Gardens, Harringay, N., clerk, one share. Registered office: 46, Leadenhall Street, E.C.

BLANTYRE ENGINEERING CO. LTD. (9,687).—Private company. Registered in Edinburgh, on October 20th. Capital, £10,000, £1 shares. Engineers, etc. Directors: A. Little, C. Rogerson, and J. McKay. Secretary: A. Little. Registered office: Blantyre Engineering Works, Blantyre, Lanarkshire.

JOHN WILLIAMS AND CO. (WISHAW) LTD (9,686).—Private company. Registered in Edinburgh, October 18th. Capital, £50,000, in 5,000 shares of £10 each. To take over the business of Excelsior Ironworks, Wishaw, with all the plant, etc. Directors: J. F. Williams and A. H. Williams. Qualification, £10. Solicitor J. C. Bishop Glasgow. Registered office: Excelsior Ironworks, Wishaw.

A. OLIER AND CO. LTD. (145,185).—Private company. Registered October 30th. Capital, £3,000, £1 shares. Seed-crushing machinery makers, etc. Directors: A. Olier and P. Rousillon. Qualification, one share. The directors may issue debentures and debenture stock up to £3,000. Registered office: 1-4, Norfolk House, Laurence Pountney Hill, E.C.

GLENDOWER AIRCRAFT CO. LTD. (145,157).—Private company. Registered October 26th. Capital, £3,000, £1 shares. Manufacturers of and dealers in aircraft, motor cars, and vehicles and their component parts and accessories, etc. Registered office: 3, Glendower Place, S. Kensington, S.W.

LEABANK MANUFACTURING CO. LTD. (145,180).—Private company. Registered October 28th. Capital, £9,500, in 7,500 preferred shares of £1 each and 8,000 ordinary shares of 5s. each. To take over, with the authority of the Board of Trade, the business carried on at Hoddesdon, Herts, and elsewhere in England, by P. and F. Doerwaldt, as the "Flender Co." (being a business the books and documents of which are liable to inspection under the Trading with the Enemy Act). Manufacturers of and dealers in wooden and metal pulleys. Clauses for assuring the British character of the company are included in the Memorandum of Association. Directors: C. J. Mortimer, F. W. Kent, and C. H. Tipple. Qualification (except first directors), 500 shares. Solicitor: A. Beckett, Amberley House, Norfolk Street, W.C.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS

**October 23rd to October 28th (inclusive).**

Alley, S. E.: Eccentrics for valve gear. 15,325, 15,326.
Alley, S. E.: Valve gear. 15,327.
Anderson, O.: Control switches. 15,054.
Barley, F. H.: Air-compressing plant. 15,184.
Baumann, K.: Semi-double-flow steam turbines. 15,376.
Baumann, K.: Radial-flow steam turbines. 15,377.
Baumann, K.: Steam turbines. 15,378.
Bell, G. G.: Transporting coal, &c. 15,291.
Bell, G. G.: Transport of coal, &c. 15,292.
Bischof, B.: Internal-combustion motors. 15,144.
Blagg, F.: Pistons, plungers, &c. 15,225.
Bretherton, F. J.: Starting-gear. 15,195.
Chadburn, W. R.: Clutch engaging and disengaging mechanisms. 15,064.
Clarke, J. C.: Clutch engaging and disengaging mechanisms. 15,064.
Coatalen, L.: Internal-combustion engines. 15,037.
Crowe, H.: Valve seatings. 15,409.
Ducker, W.: Water-power plant. 15,244.
Everett, E. I.: Electric measuring-instruments. 15,259.
Exley, W. H.: Electric accumulators. 15,366.
Flood, G. A.: Superheaters. 15,155.
Frost, C. R. B.: Internal-combustion engines. 15,219.
Godwin, D. H.: Belt-fasteners. 15,128.
Hill, J. A.: Change-speed gear. 15,407.
Hitchens, C. F.: Fuel-container. 15,186.
Holgate, J.: Reciprocating engines. 15,263.
Humphrey, A. A.: Motive-power generator. 15,134.
Inshaw, G. R.: Packing for rotary engines, 15,355.
Jay, W.: Internal-combustion engines. 15,179.
Jennings, A. L.: Couplings for direct-driven motors. 15,323.
Lowry, J. W.: Lubricant-testing machine. 15,202.
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Youster, R.: Fuel-supply device. 15,105.

## COMPLETE SPECIFICATIONS ACCEPTED.

**1915.**

13,586—Thordarson: Electric transformers.
14,842—Barclay: Drain cocks or valves.
14,861—Gornall: Carburettors.
14,914—Rutherford formerly known as Otta: Throttle valves.
15,070—Packard Motor Car Co.: Internal-combustion engines.
15,071—Abell: Carburettors.
15,074—Werts: Fluid-pressure engine.
15,230—Kelsey & Webb: Fuel blocks.
15,398—Constantinesco & Haddon: Transmitting power by fluid wave transmission.
16,101—Omnitractor Syndicate Ltd., & Smith: Motor tractors.
16,396—Higginson & Arundel: Liquid-fuel supply arrangements.
16,494—Walker: Exhaust silencers.
16,922—Griffin: Carburettors.
17,387—Watson: Pipe couplings.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

**1916.**

554—Neil, J.: Furnace bridges of steam boilers. **101,808.**
6,636—Clarke, T. W. H.: Vaporisers. **101,837.**
7,765—Moller, V.: Diaphragm pumps. **101,844.**
8,975—Blaylock, J.: Valve-controlling gear. **101,851.**

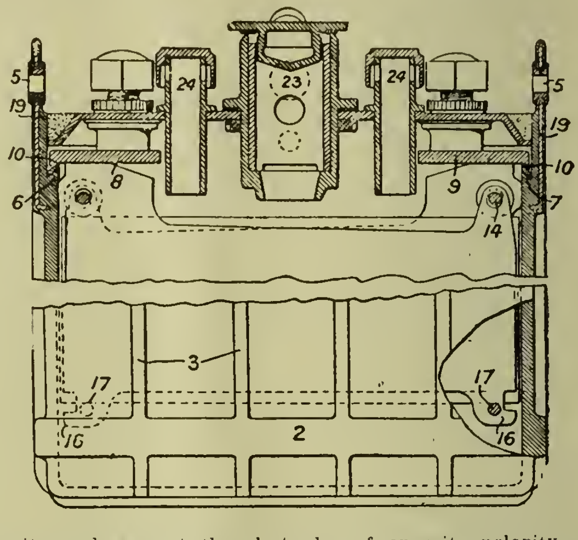
## ABSTRACTS OF SPECIFICATIONS.

### FUEL.

101,166.—J. Hani, 95, Rue St. Lazare, Paris.—A compressed fuel comprises anthracite duff, pitch or bitumen, and powdered white spar silica of the kind at Cwmystwith, near Aberystwyth. The anthracite duff is dried and heated, and the other ingredients are added in a heated fluid state, after which the mixture is further heated and then compressed into blocks or briquettes. The anthracite forms 95·97 per cent of the finished briquette.

### ELECTRIC ACCUMULATORS.

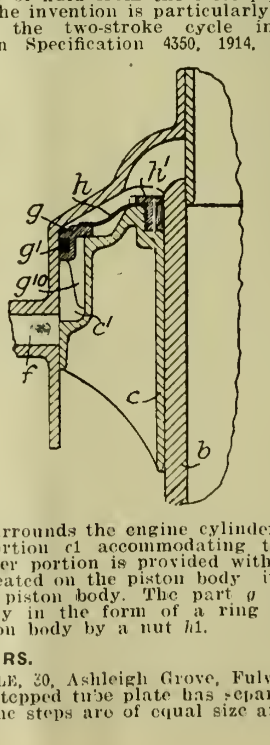
101,170.—H. Wade, 111, Hatton Garden, London.—(B. Ford, 19th Street, Philadelphia, Pennsylvania, U.S.A.). An accumulator cell is formed of rubber or the like and has transverse and longitudinal ribs 2-3, and a reinforcing material 19 in the upper part of the cell wall for strengthening purposes. The bars 8-9 to which the electrodes are attached have feet 10, which engage seats 6-7 in the cell. Insulated rods 14 pass through the electrodes of one




polarity and support the electrodes of opposite polarity. The electrodes have projections 16 at their lower corners, through which pass rods 17 carrying separators. The projectors 16 also prevent the electrodes from coming into contact with the cell walls. The cell is formed with ears and eyelets 5 for lifting purposes. Filling plugs 24 and a gas exit 23 are provided.

### PUMPS.

101,174.—G. E. Chedru, 18, Rue des Alouettes, Levallois-Perret (Seine), France.—In order to prevent undue reduction of pressure above a pump piston *c*, a portion of the periphery of the piston is formed as a valve *g* which lifts during the suction stroke and permits the passage of fluid from the inlet pipe *f* to the space above the piston. The invention is particularly applicable to the charging pump of the two-stroke cycle internal-combustion engine described in Specification 4350, 1914, as shown. The




annular piston *c* surrounds the engine cylinder *b* and is formed with a reduced portion *c*1 accommodating the annular valve portion *g*. The latter portion is provided with packing rings *g*1 and has a flange seated on the piston body. It may have wings *g*10 sliding on the piston body. The part *g* is acted on by a spring *h*, preferably in the form of a ring with spider arms secured to the piston body by a nut *h*1.

### STEAM GENERATORS.

101,184.—E. E. Noble, 30, Ashleigh Grove, Fulwell, Sunderland.—A corrugated and stepped tube plate has separated stepped tube strips B in which the steps are of equal size and equally spaced,

each step taking one tube, and in which the like edges of the steps in each strip are in a straight line, whereby all the steps are separated by an equal amount of tube-plate metal. The

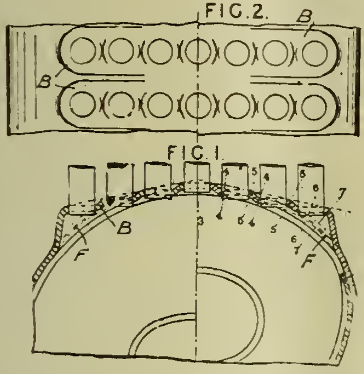
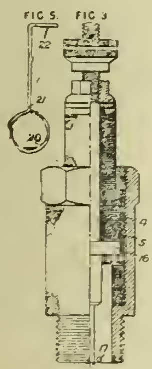



plate may be bent outwards at the sides F with greater curvature than at the middle, so as to decrease the distortion between the strips. Specifications 8407, 1900, and 17220, 1914, are referred to.

### SPARKING PLUGS.

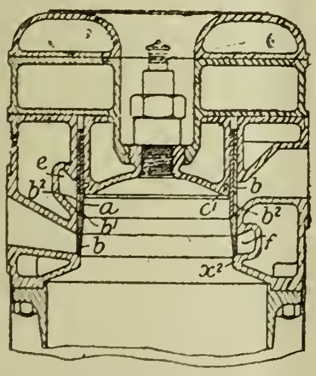
101,197.—K. E. L. GUINNESS, Aranmore, Kingston Hill, Surrey.—Gas tightness is obtained by a steel ring 16 embodied in the mica insulation 5 and insulated from either the central electrode or the casing, or both, by mica wrapping. The electrode may be of



nickel throughout, or be tipped only with that metal. A device for cleaning the combustion chamber of the plug consists of wire having a handle 20, a stem 21, and a loop 22 which is incomplete so that it may pass the bar terminal 17. Specification 24165, 1913, is referred to.

### INTERNAL-COMBUSTION ENGINES.

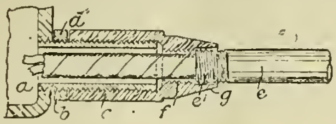
101,240.—A. W. REEVES, "Overdale," Prospect Road, Totley Rise, Derbyshire.—Inlet ports *e* and exhaust ports *f* are controlled by a pair of concentric sleeve valves *a b* which seat one at a2 upon the cylinder head, and the other at *b*1 upon the valve *b*. Inlet



ports *b*2 are formed in the valve *b*. Packing rings, pressed against the inner valve by the pressures in the cylinder, are inserted in the cylinder head at *c*1. The functions of the valves may be reversed

### ELECTRIC COUPLINGS.

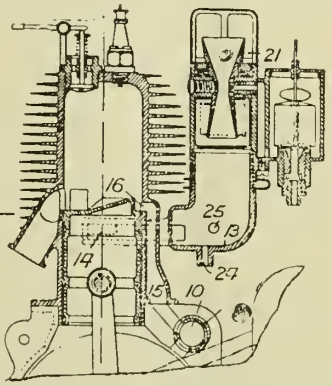
101,237.—G. H. SCHOLES, Meadow Cottage, Dean Road, Wilmslow, Cheshire.—A waterproof and electrically-continuous joint between the metal sheathing *e* of a cable and the gland *b* of a junction box *a* is constituted by forming a screw thread *e*1 on the end of the metal sheathing, passing the cable with its sheathing through the screwed gland which has screwed upon it, as shown, a sleeve *c* formed with a screw thread *f* corresponding to that on the sheathing, and unscrewing the sleeve so as to cause the thread *f* to engage the screw-threaded sheathing. To ensure a water-tight joint a screw-threaded metal washer *d* may be



brought up to the sleeve, with a packing interposed, when the sleeve is in its final position An internally enlarged part *g* of the sleeve may be left unthreaded to form a support for the cable beyond the threaded part. The screw threads between the sheathing and the sleeve may be of different or of opposite pitch to those securing the sleeve to the gland.

### INTERNAL-COMBUSTION ENGINES.

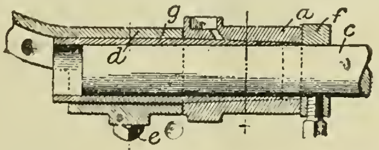
101,251.—D. RUVA, 8, Corso Re Umberto, Turin.—Mixture is admitted from the carburetter 21 to a chamber 13 having an inlet 25 for lubricating oil and a drain 24, and thence is drawn into the crank chamber through diametrically opposite ports 14,



which are uncovered by the piston at the end of the upstroke. The transfer passage 15 is controlled by a sleeve valve 16 rotating about a fixed cylindrical seating 10. The ports 16 occupy nearly half the circumference of the cylinder.

### BEARINGS.

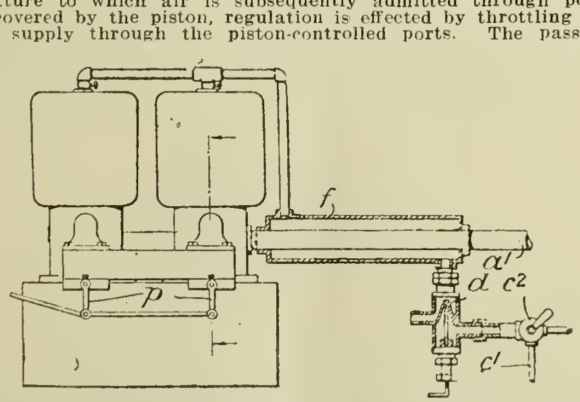
101,277.—E. D. ROY, Greenville, South Carolina, U.S.A.—To take up wear in a bearing for the rock shafts of looms, etc., a tapered bush *g* fixed to the shaft *c* and engaging a conical bearing *a* is adjusted endways. The bush is clamped to the shaft, together



with a sleeve *d*, by screws *e* which pass through slots in the bush. A collar *f* or a bearing at the other end of the shaft prevents end movement. The bush may be used for repairing worn shafts.

### INTERNAL-COMBUSTION ENGINES.

101,254.—P. DEMPSEY, 569, West 185th Street, Manhattan, New York, U.S.A.—In a four-stroke cycle engine which induces during the early portion of the suction stroke a rich non-combustible mixture to which air is subsequently admitted through ports uncovered by the piston, regulation is effected by throttling the air supply through the piston-controlled ports. The passage

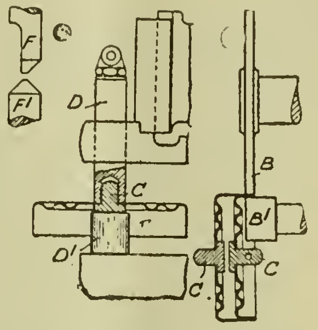


leading to each port contains a non-return valve and a hand-controlled throttle valve carrying an actuating arm *p*. The rich mixture supplied to the cylinders is prepared in a carburetter *d*

and heated subsequently in a chamber $f$, through which passes the exhaust pipe $a1$. A cock $c2$ controls the normal fuel supply or the admission of a light fuel at starting.

### STEAM TRAPS.

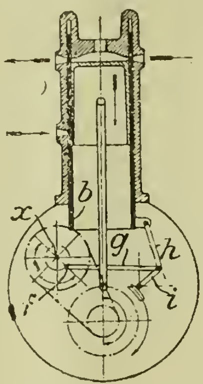
101,256.—STEAM FITTINGS CO., and B. WIESENGRUND, Horton Bridge, Yiewsley, Middlesex.—A capsule containing a volatile liquid and its vapour for operating a steam trap by its expansion and contraction is formed of steel hermetically sealed by welding to enable it to withstand high pressures and temperatures. The edges of the two plates forming the capsule may be welded together by mounting them between two slowly rotating



electrodes B B1, as shown in Fig. 1. The head of each central steel stud C may be welded to its plate by the use of electrodes D D1, the electrode D being hollow to accommodate the stud, as shown in Fig. 3. Spot welding may be employed, using pointed electrodes F F1, Fig. 4, or an arc may be established between a soft iron electrode and the seam to be welded, the fusing electrode being passed slowly around the seam with the arc maintained.

### INTERNAL-COMBUSTION ENGINES.

101,267.—L. F. GODEAU, 17, Arlington Road, West Ealing, and P. BRIGHT, 4, St. Andrew's Place, Regent's Park, both in London.—In a four-stroke cycle engine having a sliding sleeve valve $b$ co-axial with the cylinder, as described in Specification 655, 1915,

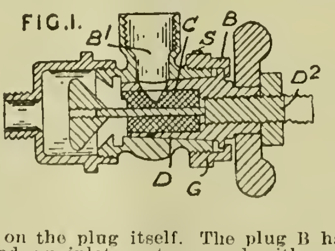


a quick movement is imparted to the valve at the ends of the inlet and exhaust strokes by mechanism comprising links $h\,i\,g$ actuated by a crank $f$ on a half-speed shaft $x$.

### VALVES.

101,324.—W. A. WILSON, Carlton Works, Armley, Leeds.—May 15th, 1916.—A plug cock combined with a screw-actuated lift valve particularly applicable for use as a gas tap, has the actuating screw mounted in the larger end of the plug and has a seat for the lift valve provided towards the smaller end of the plug either

FIG. I.



on the casing or on the plug itself. The plug B has an internal knighting pin and an inlet port covered with gauze C, and is held to its seat by a screwed annular ring G secured by a set-screw S. The coned lift valve member is screwed to the spindle D, which has a screwed part D2 working in a corresponding thread formed in the plug.

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# THE Industrial Engineer.

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# EDITORIAL.

## THE UTILISATION OF COAL.

THERE is no subject so important to industrial engineers as that relating to the economical utilisation of coal. Much has been written upon the subject, and yet it retains comparative freshness, and is capable of being interestingly treated from many points of view. The reason for this is, doubtless, that we depend mainly for the production of power on this natural element, always, of course, save and excepting where power can be developed from other natural supplies of energy such as oil, and as in the case of falling water, which, comparatively speaking, is only possible in mountainous countries. The latter is on this account out of reckoning for the vast bulk of industrial purposes, and we are driven back to rely principally upon our old friend coal to serve the industrial interests of mankind, and likewise its no less important functions in the domestic field.

In a recent contribution on the question of "Coal and its Utilisation," delivered to the Society of Arts at one of its recent meetings, Professor S. S. Brame, of the Royal Naval College, Greenwich, said that in 1913 we reached our maximum output with 287,430,473 tons, of which about 189,000,000 tons were retained for home use. The rate of production of the United States and Germany of recent years had increased far more rapidly than our own. Not only were we exhausting our supplies at a far higher proportionate rate than our nearest commercial rivals, but we retained for home consumption a much smaller proportion of our output. If Great Britain was to maintain her position as a great manufacturing nation, cheap coal was essential, and every care must be taken to avoid waste in production and utilisation. While admitting the exportation of coal to have been a tremendous factor in developing our industrial greatness, it should be realised that the exportation of over 2,000 million tons from 1873 to 1914 must have brought appreciably nearer, the time when we should have actually become to some extent importers of coal. Something to take the place of coal was not yet on the scientific horizon, or even promising to appear; so there was every necessity for the great coal question receiving attention and for legislative action to enforce economic production in the national sense.

Whilst it is quite true that there is as yet nothing to take the place of coal, that is to say, nothing which bulks so largely in the industrial field, it is nevertheless a fact that oil in one form or another, both crude and refined, is becoming more extensively employed for industrial purposes. The greatest concentrated example of the utilisation of oil in its refined form of petrol is seen in the present European War for transport purposes of various kinds. How many thousands of vehicles driven by petrol there are in use is only known to the controlling departments of the individual belligerent armies, but in the aggregate they must run into colossal figures. True, this use is only transport, and may be said to mainly displace horseflesh, but quite altogether apart from this use there are the vast number of engines in industrial use driven by petrol or by crude oils, the pregnant example in the latter field being Diesel or semi-Deisel engines, types of motor whose use is rapidly increasing in the industrial field.

# EVOLUTION IN VENTILATION HYGIENICS.

By James Keith, A.M.I.C.E., M.I.M.E., M.I.Mar.E., Etc.

*(Continued from page 64.)*

## 7.—VENTILATION OF OFFICES, LARGE PUBLIC BUILDINGS, ETC.

It is sometimes difficult to convince the average person that the perfect ventilation of general offices crowded with occupants is of the highest importance from a health point of view. By that is meant the making of the inside atmosphere of the offices at all times practically as fresh and comfortable as the air outside on a bright sunny day. Such a condition of things is only possible by means of mechanical ventilation.

Figs. 19 and 20 show respectively transverse and longitudinal sections of a shipping office having an open fireplace at each end, which may be taken as a good example. The diagrams, with notes, sufficiently explain the arrangement. It will be noticed that the ventilating installation recommended is very simple. It consists of a fresh air supply inlet duct carried from the outside to the centre of the room ceiling, from the lower side of which is fixed an open fan (having a 25 in. diameter air inlet) run by an electric motor with vertical spindle, the fan running horizontally and delivering the air laterally.

The fresh air is drawn from at least 12 ft. above the street level; the fan runs at from 280 minimum to 460 maximum revolutions per minute, and delivers the air (either warmed or cold) horizontally between two steel discs along the ceiling of the office from 9 ft. to 10 ft. above the floor level; the air then gradually falls towards the two fireplaces.

By means of this installation there is obtained a flow of fresh air in volume of approximately 3,000 cubic feet per minute in cold weather and 5,000 cubic feet per minute in summer without appreciable draughts—that is, a complete change of the whole air contents of the office is effected 16 times an hour in winter and 27 times an hour in summer at an expenditure for electrical current of only about ½ H.P in winter and ¾ H.P. in summer.

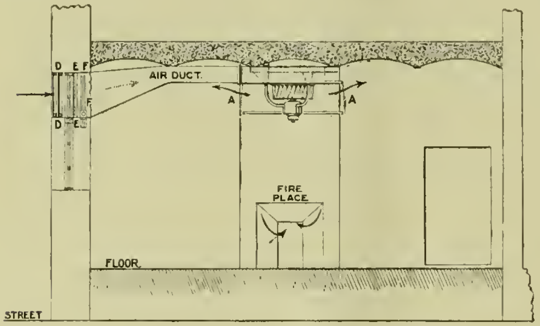
In designing the ventilation arrangements for larger and more complex buildings, much experience is requisite in order to secure anything like satisfactory results.

Nothing could better exemplify this than to point, say, to two rather typical examples in this country—*i.e.*, the Houses of Parliament, Westminster, and the Manchester Royal Exchange. In the first case cited, reference might profitably be made to the report by the author in 1894 on the "Ventilation of the Houses of Parliament," in which the then existing defects and the remedies suggested were clearly indicated.

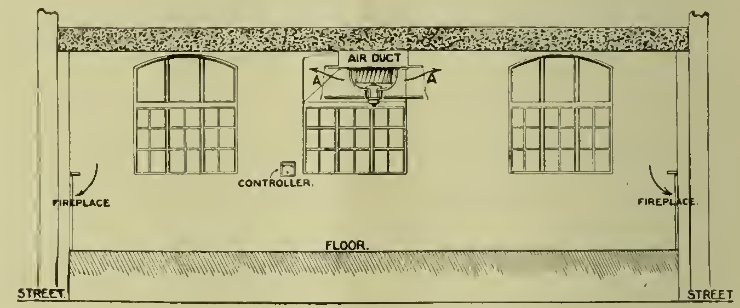
### Ventilating the House of Commons.

For instance, and as regards the House of Commons, at that date (1894), although it was shown that as much as 15,000 cubic feet of fresh air per minute was propelled into the Debating Chamber, there were almost continuous complaints about the ventilation, arising principally because of the deadly "uniformity of atmosphere," already referred to, prevalent under the galleries, where the majority of members sit. Since then (or during the past 22 years) many improvements have been effected, and although the supply of fresh air per minute has now been doubled, the results are said to be still so unsatisfactory that rearrangements—under scientific advice—are again in contemplation for securing more movement and circulation of the atmosphere inside the Chamber and under the galleries, in order that the feet of honourable members be kept warm and their heads kept cool, and that there shall be a feeling of more freshness in the air inside.

The systems of ventilation—in principle—in use in the Houses of Parliament since 1854 have been, for the House of Commons a combination of plenum and extraction, and for the House of Lords a system of extraction only, and in both cases (because of the elaborate arrangements for tempering the atmosphere in each Chamber, and the careful supervision of the necessary machinery) it must be admitted that the results obtained are free from any apparent movement in the air, which means, naturally, that the atmosphere is too still inside these Chambers to be exhilarating.




Ventilation Hygienics—Fig. 19.




Ventilation Hygienics—Fig. 20.

### The Manchester Royal Exchange.

In the case of the Royal Exchange, Manchester, quite a different set of circumstances prevails. This building is said to be the largest of its particular kind in the world; it has accommodation for 5,000 members at one time to meet regularly on its floor; and it has more displacement per unit time in ventilation (by mechanical extraction) than probably any similar kind of chamber in existence. Some two years ago the proprietors decided to enlarge the building to more than twice its present size, and lodged a Bill in Parliament for that purpose which was strongly opposed by the Manchester Corporation, one of the grounds of opposition being the alleged defective ventilation of the present building and the possibly continued inefficient ventilation of the enlarged structure. Expert evidence was, however, given before the House of Commons Committee to show that in the contemplated enlarged and reconstructed building there would in the one huge chamber be a clear floor space of not less than 55,845 square feet, and a cubical air capacity of something like 3,050,600 cubic feet, while the ventilating arrangements would provide for an air change of 18,000,000 cubic feet per hour (or three times the maximum air change per hour in the present building), which so satisfied the Committee that the Bill passed into law in due course. These figures mean that

within two or three years at most from now the new Manchester Royal Exchange will have a one-floor accommodation for 10,000 members at one time, and that each member present will have a constantly changing fresh air supply of 30 cubic feet per minute, or 1,800 cubic feet per hour.

For the comfort of members it is earnestly to be hoped that the particular scheme of ventilation, latterly decided upon, will amply fulfil requirements stated and pledged to the Committee of the House of Commons, and that the results will be eminently satisfactory.

This particular reference shows the importance Parliament now attaches to the securing of proper ventilation in large public, or semi-public, buildings where masses of people have to assemble at one time, and it is also meant to illustrate what might be called the absurdity of the carbonic acid test or guide with regard to ventilating installations of this magnitude. For instance, the atmosphere in the streets of Manchester which surround the Royal Exchange is not quite as pure and fresh, say, as the air on the surface of the North Atlantic or on Dartmoor on a bright summer day, and yet it is from these Manchester streets or directly above them that the fresh air for the ventilation of the Royal Exchange has to be obtained!

It goes without saying that new, or ideal, air cannot be manufactured, but that the air in any locality must be taken as it may exist and utilised to the best advantage. As has already been authoritatively indicated, whatever the condition of the outside atmosphere may be, if it be properly handled and treated in volume for ventilation and kept continuously moving or circulating and changing—so long, in fact, as the "essentials" are kept in view—healthful results are bound to follow. It is understood that where the external air is either impure or not free from suspicion, or is dust-laden or smoke-contaminated, it may require to be screened or cleansed (as in the case of the Singer engine room) before it is propelled into buildings containing valuable and delicate machinery and where there are workers.

It may be noted that one great advantage of the plenum method of ventilation is that, given a pure source from which to obtain the fresh air supply, all local surrounding smells are effectively kept out of the apartments or places treated, while the vitiated air is thoroughly displaced through the proper exits.

No methods other than those on the lines described and known to present-day ventilating science are available for obtaining effectively what has been called a sufficient flow of cool and relatively dry air in crowded places and especially in overheated engine rooms, "tube" railways, etc.

By these methods results are now obtainable which some years ago would probably have been considered almost impossible. The science of ventilation, with all its apparent contradictions and inconsistencies, is really a life's study, and a system that may be eminently efficient and satisfactory under certain conditions and circumstances may be quite unsatisfactory under others. There is no royal road to success in this or any other branch of technical science, but this much is certain, viz., that good ventilation cannot possibly be secured or assured in all cases (and especially under what might be called unnatural conditions) without the expenditure of money and without the aid of experience and of mechanical energy in some form or other.

*(Concluded.)*

Coal in West Iceland.—Last year explorations for coal were made in West Iceland. They were continued this summer, and showed that the coal improves as the workings go farther into the mountains.

# THE USE OF POWDERED COAL IN METALLURGICAL PROCESSES.

By C. J. Gadd.

*(Continued from page 67.)*

The use of powdered coal as a fuel in soaking pits represents probably the latest application of this form of fuel in the metallurgical arts. Fig. 12 shows a sectional elevation through a soaking pit equipped for burning this form of fuel. The drawing clearly shows the construction, and the mode of operation will be readily understood. Five double soaking pits of the general design shown are now in operation and are giving very satisfactory results.

Another recent application of powdered coal is in open-hearth furnace practice. At this time four different steel plants are using this form of fuel in open-hearth furnaces with encouraging results. While all the installations are more or less in an experimental stage and not as yet fully developed, owing to the limited time of application, the results obtained thus far have fully demonstrated the economy of powdered coal over oil and show equal economies with producer gas.

## Methods of Applying Powdered Coal to Furnaces.

Fig. 13 shows the four different methods at present employed for applying powdered coal to open-hearth furnaces.

A, B, and C represent installations in which high-pressure syphon type burners are used, similar to those shown in Figs. 5, 6, and 7. One burner is placed on each end of the furnace, the fuel being reversed as in the case of producer gas. As the gas flues are eliminated in this process, the regenerative chambers in most cases have been enlarged, and in place of checkers staggered arches or parallel walls have been built to give the necessary regenerative area. There are at the present time one 75-ton, three 60-ton, and four 35-ton open-hearth furnaces of the regenerative type in operation, with modications in the construction of the regenerative chambers as described.

At one plant the results obtained have been so encouraging that a second furnace of 75 tons capacity is now under construction.

D represents a somewhat radical departure from the old-time theories of open-hearth furnace practice. By reference to the diagram it will be noted that the burners are arranged only at one end of the furnace, the path of the flame being always in one direction. There are no regenerative chambers, air at room temperature being used for combustion of the fuel.

The theory underlying this method of applying powdered coal to open-hearth furnaces is:—

First, the fuel is burned above the bath, and all the heat contained in the coal is instantly developed in the furnace.

Second, as the path of the flame is in one direction, all parts of the furnace are maintained at the same temperature.

Third, by reason of their high radiating capacity, the infinite number of minute incandescent particles in the powdered coal communicate the heat by radiation, and not by convection, thus eliminating the necessity of bringing the surrounding air to the temperature of the coal particles.

Fourth, all the heat in the waste gases is conserved and used in the production of steam.

The extra fuel consumed, due to the use of cold air, is offset:—

First, by the elimination of all loss in the gas producer process.

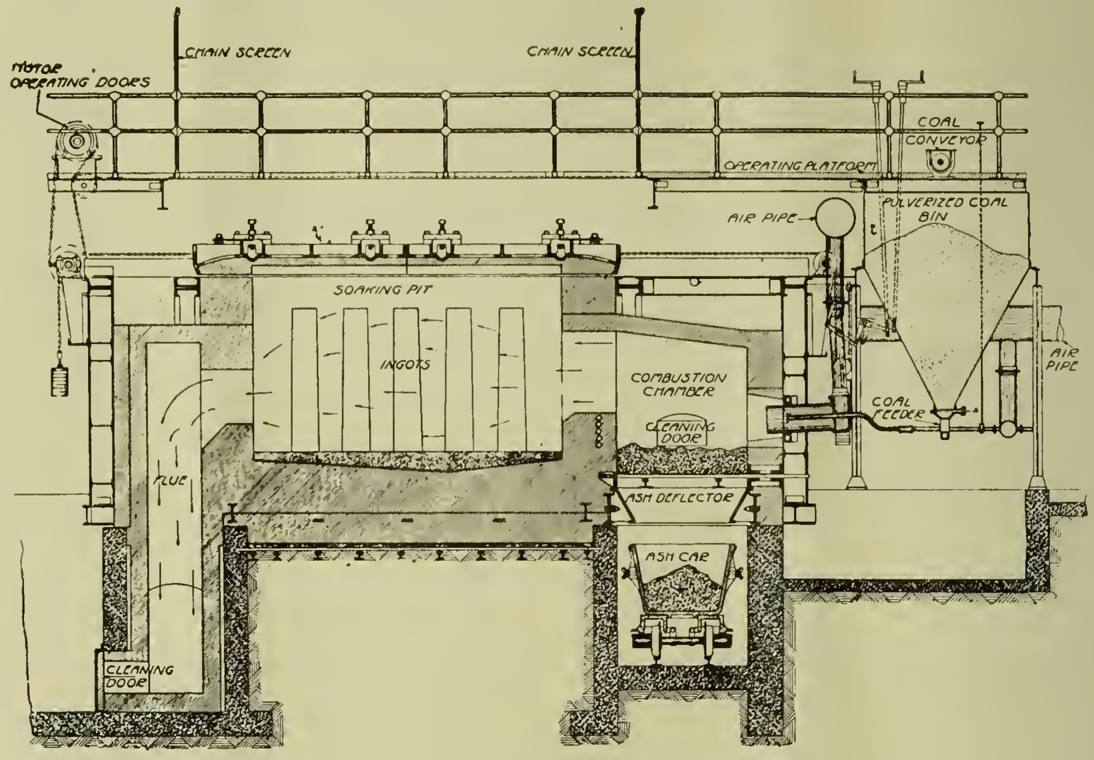
Second, by the elimination of all loss due to frequent reversals.

Third, by the elimination of all loss in waste heat taken up by the regenerative chambers.

Fourth, by the elimination of the expensive maintenance cost of producer plant and regenerative chambers.

Fifth, by the greatly reduced first cost of installation.

As powdered coal requires a high temperature for ignition and maintained combustion, there would be no incentive for the powdered fuel to ignite in the cold furnace after charging, especially since the air necessary to support combustion is also cold.

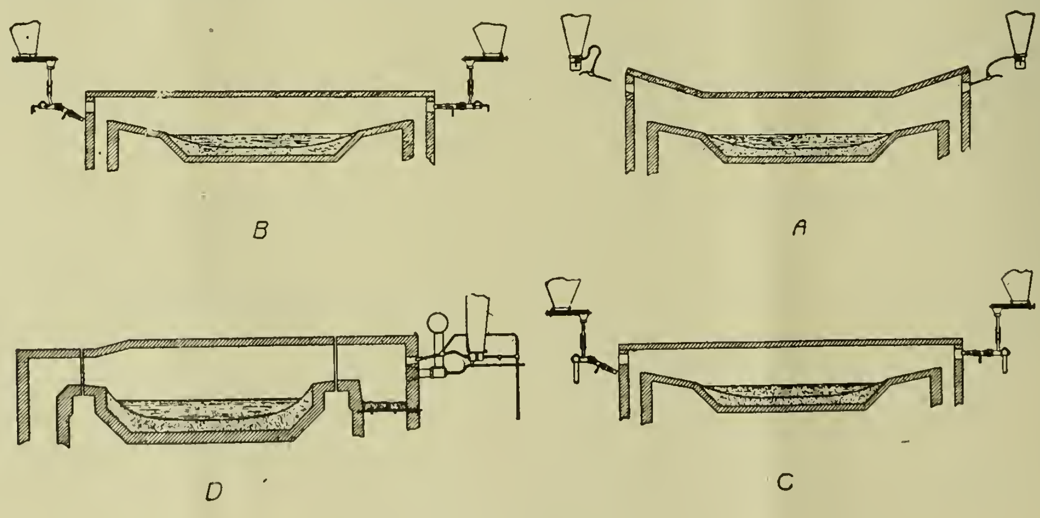



The Use of Powdered Coal.—Fig. 12.

### One of the Furnaces.

Fig. 14 shows a sectional elevation of this furnace. A section through the combustion chamber looking towards the back wall is shown in the upper left-hand corner. By reference to this view it will be noted that three burners are employed—the central one of the high-pressure syphon type shown in Fig. 8, the two side ones of the low-pressure type shown in Fig. 4.

The combustion chamber in this installation is maintained at a high uniform temperature at all times by the two low-pressure burners. The high temperature maintained in the combustion chamber pre-heats the air furnished to support combustion, and as the high-pressure syphon burner discharges the powdered coal through the hot zone of the chamber, complete combustion of the fuel is ensured.




The Use of Powdered Coal.—Fig. 13.

Auxiliary air for combustion is admitted through the back wall of the combustion chamber at the roof line.

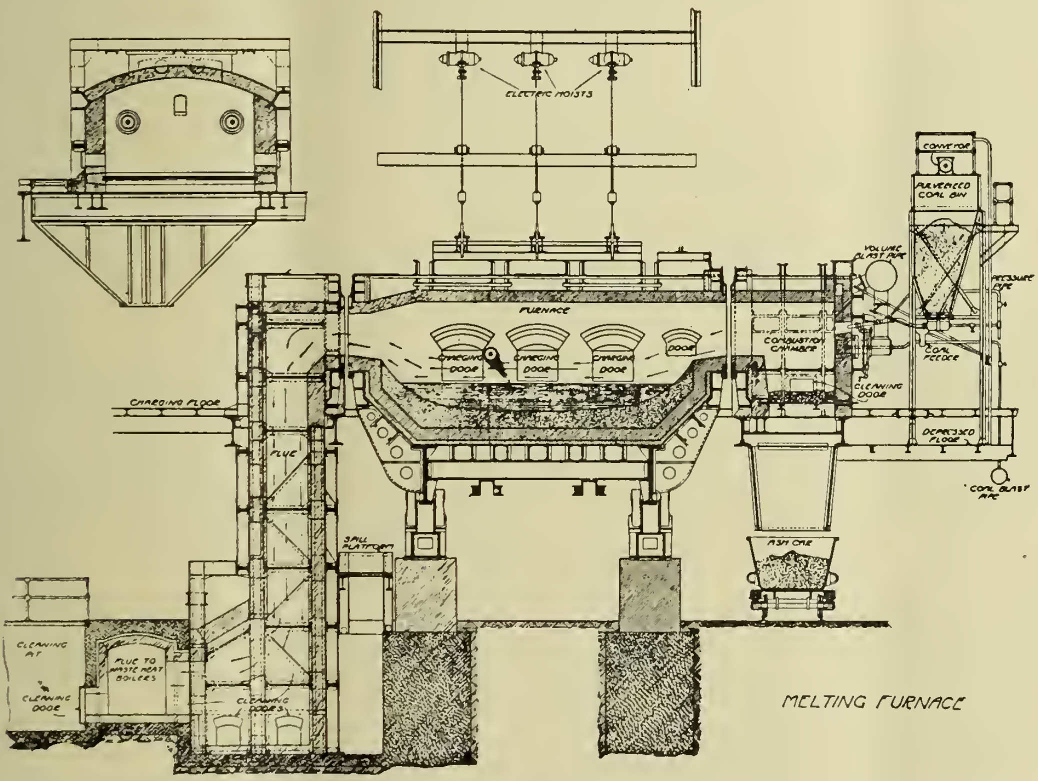
The accumulation of ash in the combustion chamber is raked out through the cleaning doors after every heat and is discharged through a trap door in the charging floor into the ash car below.

From a metallurgical standpoint the deposit of ash on the bath is too small an amount to be noticeable.

In the slag pocket at the bottom of the vertical flue the ash and the brick slag form a thick, pasty mass, the tough consistency of which makes its removal difficult. Beyond this point the ash settles in the flues as an impalpable powder. After each heat it is stirred up by inserting a compressed air jet through the separate cleaning doors of the flues. The ash clouds thus produced are picked up by the flue draught and are carried in suspension out of the stack.

The boiler tubes are cleaned with steam blowers four times each day.

The course of the waste gas is indicated by the arrow




The Use of Powdered Coal.—Fig. 14.

marks, and is shown discharging into the flue connecting with the waste-heat boilers.

## The Waste-heat Plant.

Fig. 15 shows a plan and elevation of the waste-heat plant, also a sectional elevation through the boilers and economisers. The course of the waste gases can be followed by the arrow marks, and the general operation will readily be understood by reference to the drawing.

It will be noted that by the arrangement of the flues and dampers the whole waste-heat plant may be by-passed. The economiser and both boilers may be by-passed either separately or in combination, as desired. The flexibility of this arrangement permits any adjustment or repairs to the boilers or economisers without affecting the operation of the furnace.

Within the past few months four 50-ton basic open-hearth furnaces thus arranged have been placed in operation. In this short period operating conditions have demonstrated the soundness of both the underlying theory and the engineering principles involved in this method.

Compared with producer gas, equally high temperature is attained.

Uniform temperatures throughout the furnace are maintained.

Heats can be made within reasonable time.

Fuel consumption is high. This, however, is offset by the fact that the waste-heat plant produces an average evaporation of $6\frac{1}{4}$ lbs. of water per pound of coal fired in the furnace.

Compared with the best boiler-room practice, $62\frac{1}{2}$ per cent of the fuel consumed by the furnace is used in the generation of steam, leaving $37\frac{1}{2}$ per cent chargeable to steel production. Based on this reasoning, economies over oil and producer gas are fully substantiated.

In the use of powdered coal in metallurgical furnaces we have arrived at a stage of development where fixed rules may be laid down for its application which, if strictly followed, will result in high economy and efficiency.

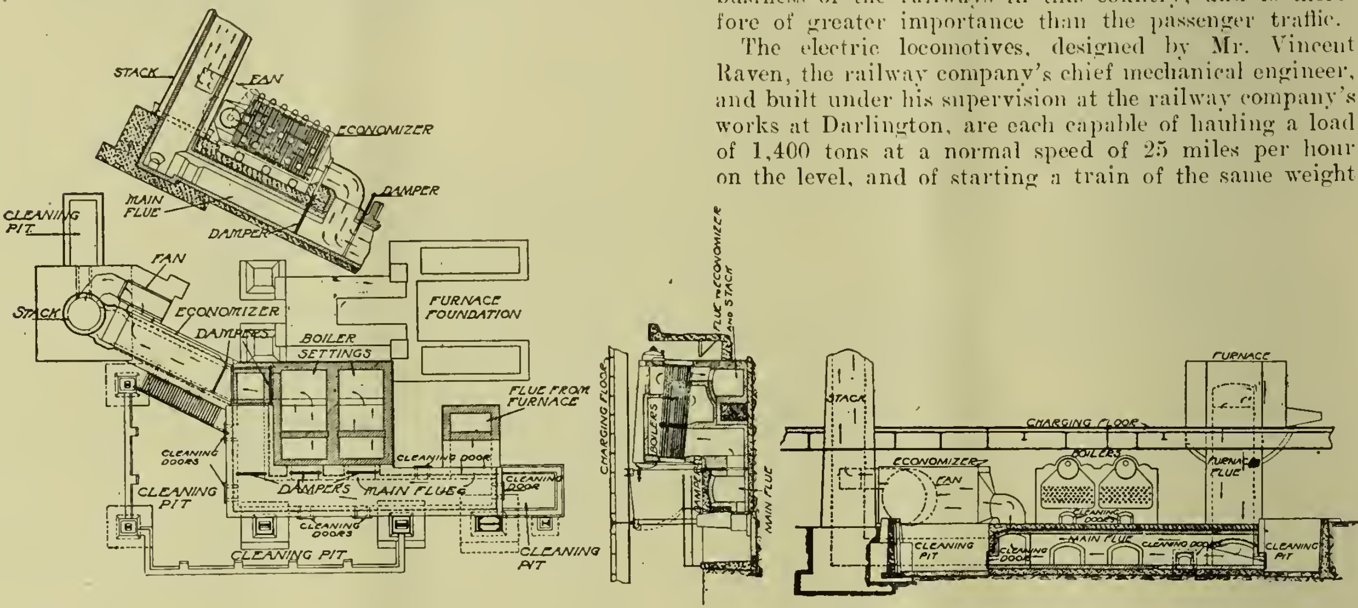
The personal equation is the important factor in operating part of the apparatus as developed thus far. It is not necessary to depend too greatly upon this uncertain element.

In the drying process the operator may at any moment upset the complete equilibrium of a plant either by overheating the coal or by not drying it enough.

In the furnace operation three or four separate adjustments are required, depending on the burner used, each adjustment bearing a fixed relation to the others. These adjustments are: The control of the coal feed, the control of the coal blast, the control of the volume blast, and the control of the furnace draught, where mechanically-operated low-pressure feeders and burners are employed, all of which controls are separately left to the judgment of the operator. When we consider that there is no fuel so sensitive to correct

application as powdered coal, and when we realise the exact precision required in its manipulation, the dependence placed on the personal element is at once apparent.

In order to obtain uniform conditions, it is necessary to eliminate the personal equation as far as possible. In the drying process this might be accomplished by an automatic control of the coal feed governed by the temperature of the dryer cylinder. In the case of the burners and feeders this might be done by a single adjustment regulating and supplying the correct proportion of air and coal, with provision for adjusting the air and coal independently in order to obtain correct proportions for different grades of fuel, thus producing an absolutely uniform combustible mixture, which will be maintained, regardless of the quantity supplied after once setting the adjustment.




The Use of Powdered Coal.—Fig. 15.

The high economy and efficiency of powdered coal in the metallurgical processes, under the limited application of this fuel and the limited development of apparatus, provide an index of its possibilities under more general use. With a further development of apparatus this form of fuel doubtless will eventually supplant oil, tar, and producer gas in the varied fields where they now hold supremacy.

*(Concluded.)*

## FUEL ECONOMY ON THE NORTH-EAST COAST AS A RESULT OF ELECTRIC POWER SUPPLY.

By R. P. Sloan.

*(Continued from page 72.)*

The credit of electrifying the Newcastle suburban railways is, of course, due to the enterprise of the North-Eastern Railway Co.; but the fact that they were the first important English railway to electrify a portion of their system, and that they purchased the necessary electricity from the Power Co., shows that the availability of cheap power is an advantage not only to manufacturers but to the public generally in facilitating the introduction of electric traction. Since the electrification of the Newcastle system the train service has been more than doubled and the shedule speed improved by 20 per cent. A comparison with other cities at home and abroad shows that no other town of similar population has so extensive an electrified railway system or so frequent a suburban service, and this has, of course, resulted in a large increase of travel.

The Newcastle and coast surburban railways were electrified more than 10 years ago. More recently the North-Eastern Railway Co. have applied electricity to a freight line, and have electrified some 50 miles of track on their Shildon-Newport route, which carries the heavy mineral traffic between the coalfields of South-West Durham and the blastfurnaces and ironworks of the Middlesbrough district. Few people realise that goods traffic forms the greater portion of the total business of the railways in this country, and is therefore of greater importance than the passenger traffic.

The electric locomotives, designed by Mr. Vincent Raven, the railway company's chief mechanical engineer, and built under his supervision at the railway company's works at Darlington, are each capable of hauling a load of 1,400 tons at a normal speed of 25 miles per hour on the level, and of starting a train of the same weight on a 1 in 300 gradient. No special generating station has been built, the whole of the current required being supplied by the power companies, whose existing mains are tapped at two points where they touch the railway.

The supply of electricity to coal mines—though the important colliery areas were not touched until some five years after power supply started on the Tyne—has not reached a high state of development. It is estimated that, apart from the smaller colliery supplies, pits having an output of over 20,000,000 tons of coal per annum now depend upon the power companies for their power supply. The uses to which electricity is put include pumping, hauling, ventilating, winding, etc., and, as elsewhere, the simplicity and general advantage of the electric motor over all other forms of engine has made itself apparent. It is estimated, in the case of collieries, that at least 75 per cent of the coal previously used for power purposes has been saved as a result of burning it at the economical generating stations of the power companies instead of each pit generating its own power; this is equivalent to a saving of at least 1,000,000 tons of coal per annum, apart altogether from the saving of coal resulting from the utilisation of waste heat, discussed later, and the saving of coal used for producing power for shipbuilding and engineering works and for the railways.

One of the most interesting features of the problem that had to be dealt with, and which it is not too much

to say is also of considerable national importance, was the utilisation of the waste heat in the district. The counties of Northumberland and Durham and the North Riding of Yorkshire produce some 7,500,000 tons of coke per annum. The bulk of this used to be made in the old-fashioned beehive ovens, but during the last decade the retort type of oven has made rapid progress on account of its increased coke yield and the value of the by-products recoverable. The waste heat from these ovens and from the blastfurnaces and the exhaust steam from blowing engines in the Cleveland district form a considerable source of power.

The problem of the utilisation of this waste heat has been solved by the establishment of local generating stations, where such surplus power is available. These plants feed into the main power company's system and the stations work in parallel with the five main generating stations of the power companies. These local generating stations, or "Waste Heat" stations as they are commonly called, are run so that they each supply the maximum amount of energy possible—depending on the supply of waste heat or steam available—all regulating being done by the main power stations.

The power company need install no spare plant in any of the waste-heat stations connected to its system, being able to meet any variation of load by means of its coal-fired stations, which also act as stand-by against any breakdown. Moreover, the power company, having a market for current many times greater than the output of any individual waste-heat station, is able to run such stations continuously at their maximum output capacity, so utilising completely all the current that can be produced therein; whereas it is impossible to conceive the power requirements of an individual coke-oven and colliery installation coinciding even approximately over 24 hours with the amount of gas or waste heat available.

The first waste-heat station was erected in 1905 by the Priestman Power Co., a subsidiary company formed jointly by the Priestman Collieries Ltd. and the Newcastle-on-Tyne Electric Supply Co. Ltd., at Blaydon, in conjunction with new coke ovens then being erected by the Priestman Collieries Ltd., who were the first to see the advantages of co-operating with the power company.

There are now 11 waste-heat stations in operation in the North-East Coast area, and in a typical day's working of two such electrical generating stations the waste heat available is sufficient for the generation of an amount of power very considerably in excess of that required by the colliery owners. As a matter of fact, during the year 1915 these two stations alone turned out 40,000,000 units, of which only 10,000,000, or 25 per cent, were required for the working of the collieries, the remaining 30,000,000 units being delivered into the mains of the power supply company. The total coal saving due to utilisation of waste heat in the North-East Coast now amounts to some 150,000 tons per annum.

This brief account of what has already been done on the North-East Coast will show the great economy which has been effected. There can be no doubt that a proper appreciation of the enormous economics which may be effected by the avoidance of inefficient and wasteful separate power installations, and by the pooling, not only of all power requirements of all kinds, but also of all power-producing plants, into one inter-connected power supply system in each industrial district, will be one of the most important factors in that general development of the country's industries which we are all hoping to see.

*(Concluded.)*

## NATIONAL ELECTRIC POWER SUPPLY.

We have received from the Hon. Secretaries of the Joint Committee appointed by the Incorporated Municipal Electrical Association and the Incorporated Association of Electric Power Companies to consider the question of the linking-up of electricity supply undertakings, a copy of a Memorandum which has been sent to the various town clerks and engineers of municipal supply undertakings, and to the secretaries and engineers of company supply undertakings, together with a letter suggesting that the addressee should attend a general meeting of all the undertakings situated in the group or area in which it is suggested that that particular undertaking should be included, with a view to discussing the Memorandum and appointing a local committee as indicated therein.

The problems to be considered by the local committees include:—

1. The consideration of the areas shown on the accompanying map with a view to their better division if considered desirable.
2. The best methods of inter-linking the existing generating stations with a view to their more economical operations, and to the better security of the supply.
3. The best means of providing the capital required for the plant and mains that are necessary, and for the equitable allocation of the same.
4. The best methods of payment between undertakings for any current supplied or interchanged.
5. Any special local arrangements that are considered desirable.

The Memorandum, after referring to the importance to the electric supply industry of the Board of Trade circular letter of May 25th, 1916, and to the forming of the Joint Committee to consider the question of linking-up in all its aspects, states that the importance of linking-up several large stations, and equally of linking-up large stations with small ones, where such linking-up can be carried out without undue capital expenditure, is now becoming more generally realised.

The Joint Committee has arrived at the following conclusions with regard to the suggestion contained in the Board of Trade letter:—

1. That linking-up is important for the purposes of saving fuel, saving labour and increasing the security of supply, and, in the future, making for economy of capital.
2. That the question of linking-up should be considered broadly from the national point of view, and having in mind not only the saving of fuel but the interests of consumers in obtaining a cheap supply of electricity for all purposes.
3. That while the generation of electricity as distinct from its distribution must be considered broadly and irrespective of the present areas of electricity supply undertakings, clearly all existing rights must be respected and existing areas must not be interfered with as regards distribution.
4. That the linking up of many existing stations could be carried out immediately without further legislation.
5. That in order to arrive at a better understanding of the problem, committees of engineers representative of local electricity supply interests should be appointed in various parts of the country.

To facilitate the formation and work of the local committees the accompanying map has been prepared showing

a provisional sub-division of the country into areas, but if local circumstances (known better to engineers) in any area make it desirable to alter the definition of these areas, it is, of course, open to them to suggest any such alteration.

A local committee has already commenced work in the Lancashire area, and the schedule appended shows the information that the committee decided to obtain.

If the local committees will communicate from time to time to the joint committee the results of their labours, the experience gained by each local committee can be made available for the use of all, and the joint committee is prepared to assist in every possible way.

An Appendix "A" gives two examples showing advantages which in practice have been realised by linking-up, and an Appendix "B" contains a diagram and descriptions illustrating an arrangement likely to be found applicable to many actual cases.

The Memorandum is signed by the following:—Messrs. J. H. Bowden, W. A. Chamen (Chairman), R. A. Chattock, J. S. Highfield, W. W. Lackie, Charles H. Merz, S. L. Pearce, Thos. Roles, D. A. Starr, W. B. Woodhouse; Hon. Secretaries, H. Faraday Proctor, The Exchange, Bristol, and A. de Turckheim, Caxton House, Westminster, S.W.

An explanatory note attached to the Memorandum states that the first public distribution of electricity was carried out by companies working under Provisional Orders granted under the Electric Lighting Acts, 1882 and 1888. Under these Acts their plant and mains are subject to compulsory purchase after 42 years from the date of the Order, and thereafter after recurring periods of 10 years.

The practicability of the business having been proved, many municipal corporations entered the field, supplying in their municipal areas under Provisional Orders, and in other cases they bought up the undertakings of local companies under agreement or arbitration.

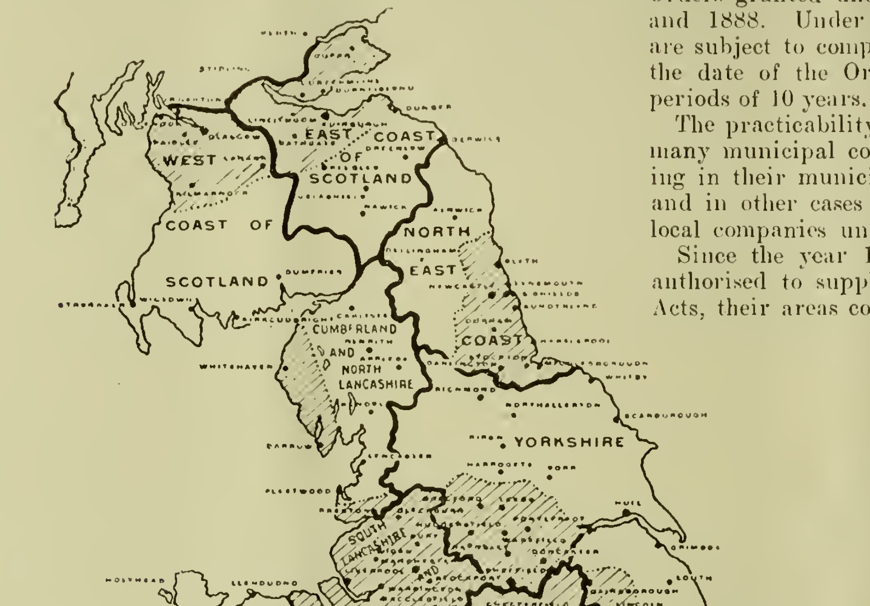
Since the year 1900 several companies have been authorised to supply electricity under Special Power Acts, their areas covering the greater part of the industrial districts of the country, and these undertakings are not subject to compulsory purchase.

These three groups provide all the public electric supply in the country, but there are still various tramway undertakings, railway companies, and other industrial concerns providing their own electric supply from independent power stations.

Sufficient time has elapsed, and sufficient experience is available, to show the defects of the original legislation. Experience has shown that the comparatively small areas of the companies and local authorities working under Provisional Orders are, in many cases, insufficient to enable advantage to be taken of modern improvements in plant. It is also evident that the liability to compulsory purchase imposed upon the undertakings of companies working under Provisional Orders has restricted enterprise and retarded the development of electricity supply. Since some of the companies operate in very important districts, immediate measures should be adopted to deal with this difficulty.

One of the most important problems, both at the present time and in the future, is the better utilisation of our coal supplies. An extension of this problem consists in utilising the coal in such a way as to avoid the waste of its valuable constituents and by-products. This object can be attained in a very satisfactory way only by treating the coal at central points on a large scale. Electricity offers by far the most economical and convenient method of distributing the power from these centres.

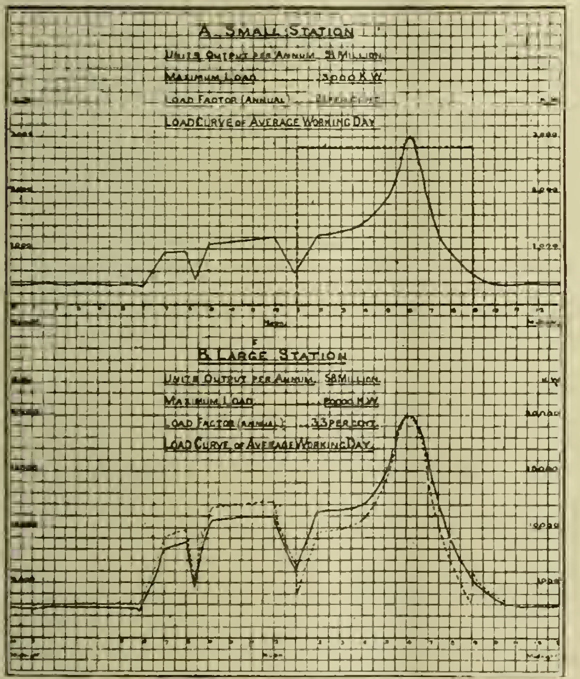
The following is the schedule of information desired by the Lancashire Local Committee:—(1) Name of authority; (2) area of supply; (3) system of generation




National Electric Supply: Map showing suggested sub-division into Areas. Industrial Areas Shaded.

and transmission; (4) voltage of generation and transmission; (5) periodicity of system; (6) capacity and type of generating plant installed; (7) total plant capacity in kilowatts installed, (*a*) A.C., (*b*) C.C.; (8) capacity of boiler plant installed, expressed in kilowatts; (9) coincident maximum load on system in kilowatts 1915-16, (*a*) generated, (*b*) purchased; (10) expected coincident maximum load in kilowatts 1916-17, (*a*) generated, (*b*) purchased; (11) effective generating plant capacity in kilowatts when plant on order is completed, giving date of latter; (12) facilities for future extensions on existing site; (13) contemplated extensions on new site; (14) maximum Sunday load in kilowatts, (*a*) in winter, (*b*) in summer; (15) total kw.-hours for last completed financial year, (*a*) generated, (*b*) purchased; (16) general remarks.

*Appendix "A."*—(Actual Results of Linking-up.) I.—Two power stations, each carrying about 7,000-kw. of load, were linked up at a cost of £3,000, the link having a capacity of 3,000 to 4,000 kw.




By shutting down one station each night (12 midnight to 6 a.m.) and week-ends (from noon Saturday to 6 a.m. Monday): (1) The plant load factor at each station has been increased from 67 to 72 per cent; (2) the total saving of coal per annum in both stations has been 2,000 tons, and it is anticipated that this saving will be increased to 3,000 tons.

II.—A power station having a maximum load of 2,000 kw. was linked up with another power station having a maximum load of 15,000 kw.

(1) During the second year of working "linked-up," the coal consumption of the smaller station was reduced by 2¼ lbs. of coal per unit on all units generated by that station; (2) the combined saving of coal, due to interchange of current, in the second year of working, amounted to 5,500 tons.

In addition to the saving of coal, linking-up has resulted in the following further advantages:—(1) Greater security of supply, (2) reduction in the number of shifts run and wages paid, (3) reduced maintenance charges due to fewer plant hours run, (4) facility for carrying out repairs when stations are shut down, (5) a saving in future capital expenditure owing to reduced amount of stand-by plant and the use of larger generating sets.

*Appendix "B."*—(Linking-up Proposal.) A power station (A) having a maximum load of 3,000 kw. links up with another power station (B) having a maximum load of 20,000 kw.

(A) runs for 8 hours (one shift) a day only (and possibly not at all on Sundays), (B) taking the load during the remaining 16 hours. During the 8 hours when (A) is running, which would include (A's) peak load, (B) would transfer to (A) sufficient load to keep (A) at a uniform load of 2,800 kw. except at the hours when (A's) own load is 2,800 kw. and over. Such a division of load would result in maintaining (A's) output at 5½ million units while increasing his plant load factor threefold, (B's) load factor remaining unaltered, while the units delivered from (A) to (B) during the 8 hours when (A) is running would be returned by (B) to (A) during the remaining 16 hours.

*Advantages.*—(1) Fuel saved; because (A's) load is always sufficient to enable all machines running to be run at most economical load, and (B) gets a better load during the slack hours. A saving of 1 lb. of coal per unit on 5½ million units is equivalent to 2,500 tons per annum, or, at present prices, say, £1,500 to £3,000, depending upon the locality.

(2) Wages saved; because (A) works one shift instead of three, thereby saving more than half his wages bill and reducing his maintenance charges (because of fewer plant hours).

It will be seen that such arrangements would not only result in a saving to the nation of 2,500 tons of coal per annum, but a saving to the two electric supply undertakings of, say, £3,000 per annum, including wages, etc., which would give a return of 10 per cent even if it cost £30,000 to connect up.

(*To be continued*).

THE DEEPEST MINE WORKS.—The deepest mine works in any part of the world are in Brazil. One of the mines of St. John Del Rey Mining Company Limited has reached the vertical depth of 5,826 ft., and since the vein shows no sign of losing its size or value the company is considering means of continuing to a vertical depth of 7,626 ft.

"SOME" LUBRICATION.—Lubricating 512,840 square feet at a cost of one cent was the record established for a 20 in. by 32 in. Norberg poppet-valve engine installed in the plant of the Rockwell Manufacturing Company, Milwaukee, Wis. This figure was made in July of this year when the engine ran 224½ hours at a speed of 150 revolutions per minute. In this period two gallons of cylinder oil was used, and the total cost of lubrication was 1·10 dollars. The area of the cylinder swept by the piston rings at each revolution was 27·92 square feet, and the total surface swept in the month was 56,412,360 square feet. The engine used superheated steam at a gauge pressure of 150 lbs. and a superheat of 120 deg.

AN AMERICAN SELF-STARTER.—An American self-starter for aeroplane engines based on the employment of compressed air has recently made its appearance, says the *Scientific American*. To start an engine with this device air contained in a tank is drawn through a control valve to a special carburetter, where it picks up petrol in a thoroughly vaporised form. Through an automatic distributor the compressed gas is fed to the engine cylinders in firing sequence. The compression is sufficiently high to cause the first piston—that on the compression stroke—to move downwards; sparking takes place, and the motor soon acquires its normal speed. Compressed air is stored in the air tank by means of a small compressor driven by the aeroplane engine.

## BOILER-HOUSE EFFICIENCY.



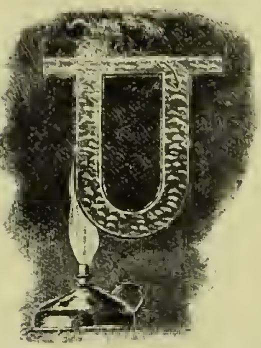
*(Specially contributed.)*

(*Continued from page 52.*)

HEAT TRANSMISSION.

### Circulation in Water-tube Boilers.

We have previously considered how the water circulates in the usual types of fire-tube boiler. In such boilers the water movements are not controlled, but can take a path which offers the least resistance at any par-



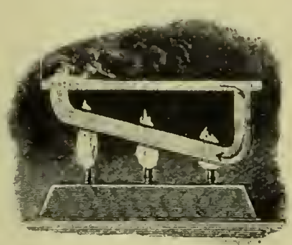


FIG. 77. BOILER-HOUSE EFFICIENCY. FIG. 78.

ticular moment. The movement of the products of combustion is, however, fairly well controlled, as in all fire-tube boilers the gases must move along the designed path.

With water-tube boilers, both the water movements and the movements of the products of combustion are fairly well controlled, and consequently it is possible to obtain in such boilers both gas and water speeds which investigation reveals as giving the most economical results in any particular plant.

### Experiments on Water Circulation in Tubes.

An experiment with a model made by Williams was described and illustrated in Fig. 70 (*Industrial Engineer*, Oct. 7th, 1916). The movements of the water being clearly understood and provision made for these movements, an apparatus was obtained which gave ideal

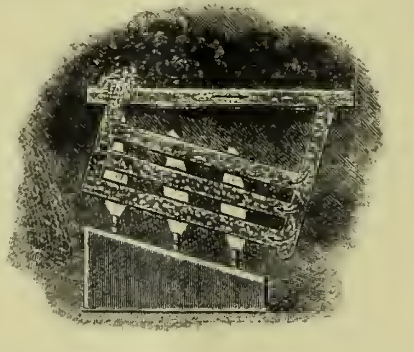


FIG. 79.—BOILER-HOUSE EFFICIENCY.

water circulation. As far as the writer knows, Williams made no quantitative measurements with this apparatus, either with regard to speed of water, heat transmission, or water evaporated, but confined himself solely to showing the advantage of separate paths for the feed and for the rising water and steam.

A series of interesting experiments made by George H. Babcock are shown in Figs. 77-79.

Fig. 77 shows a U-tube attached to a vessel containing water. On heat being applied, circulation of the water is set up in the direction shown by the arrows.

Babcock states: "This U-tube is the representative of the true method of circulation within a water-tube boiler properly constructed." In order to obtain greater heating surface, the heated leg of the tube can be made into a long incline, and we have the arrangement shown in Fig. 78. By adding other tubes, the heating surface may be still further increased, and we have the arrangement shown in Fig. 79, which is an extension of the U-tube experiment, and also the basis of the design of the well-known inclined-tube generator.

The best-known experiments on water movements in

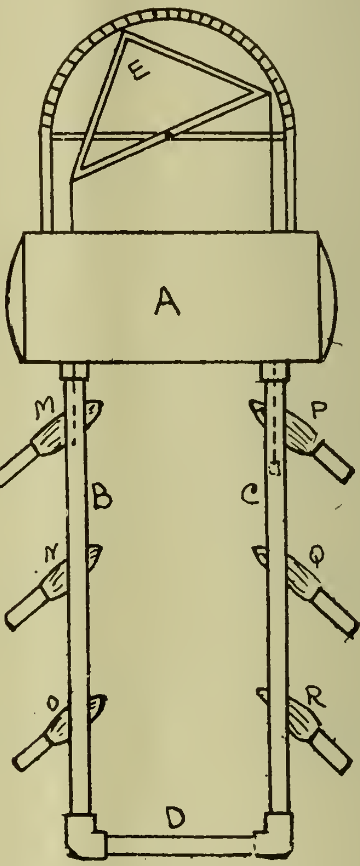



FIG. 80.—BOILER-HOUSE EFFICIENCY.

water-tube boilers were made by Yarrow a few years ago, and although it is not possible to deal with all the experiments fully, the following notes will indicate the method of making and the results obtained from the earlier experiments. The apparatus used is shown in Fig. 80. To the vessel A two glass tubes B and C were attached, which were connected at their lower ends by means of the tube D. Arrangements were made for applying heat to either or both of the glass tubes, and also for measuring the relative velocity of the water with each alteration of the quantity of heat applied. The method of measuring this relative movement was as follows: Fixed on the top of vessel A is a semi-circular index plate and rotating on a pin fixed in the centre of this index plate is the triangular frame E. Suspended from the corners of this frame are two weights, one hanging in the water in the glass tubes and the other attached to the frame.

It will be evident that, as the water movements in the glass tubes vary, the point on the triangle will indicate a different position on the index frame.

The markings on the index frame were negative on the left-hand side of the centre position and positive on the right hand. The results obtained were as follows:—

| | | |
|---|---|---|
| No heat applied. | | Pointer at −45. |
| 1 burner at M. | | Pointer position unsteady. |
| 2 burners at M and N. | | ,, ,, −12. |
| 3 ,, | M, N, and O. | ,, ,, −5. |
| 4 ,, | M, N, O, and P. | ,, ,, +10. |
| 5 ,, | M, N, O, P, and Q. | ,, ,, +15. |
| 6 ,, | M, N, O, P, Q, and R. | ,, ,, +20. |

In these experiments the tube C acted as downcomer supplying the new feed water, and B acted as the riser. It will be noticed from the above results that when once the direction of circulation is started up increase of heat even on the downcomer has the effect of increasing the rapidity of circulation.

Yarrow endeavoured to measure the actual velocity of the water in the downcomer by inserting a small screw.

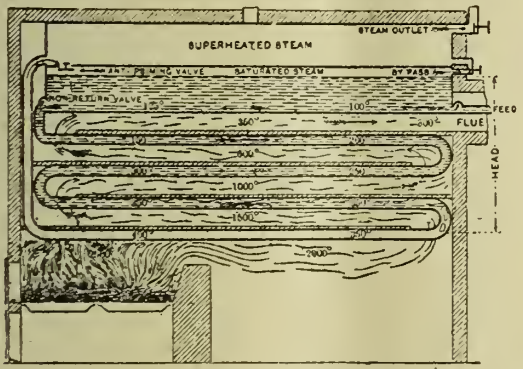



FIG. 81.—BOILER-HOUSE EFFICIENCY.

which was revolved by the water, and the number of revolutions measured. From this figure the water velocity was obtained. The results obtained were as follows:—

| | | |
|---|---|---|
| 2 burners on riser tube | | Water speed, 28ft. per sec. |
| 3 ,, ,, | | ,, 36ft. ,, |
| 3 ,, ,, | 1 on downcomer. | ,, 42ft. ,, |
| 3 ,, ,, | 2 ,, | ,, 49ft. ,, |
| 3 ,, ,, | 3 ,, | ,, 55ft. ,, |

Circulation is therefore increased as more heat is applied, irrespective of the proportion absorbed by the up and down tubes.

Now the velocity of the water obtained in the above experiments is due mostly to the difference in weight of the contents of the "riser" and "downcomer." This difference produces a head which causes the flow of water. Calculations made by experts like Booth and Thorneycroft show that in actual water-tube boilers the velocity of the water is so high that each particle of water will make from 100 to 600 circuits before being evaporated.

In order to obtain the maximum head necessary to produce maximum possible velocity, we should require:—

(a) A vertical downcast with only water in it.

(b) A vertical upcast with only steam in it.

(c) Complete evaporation secured in a tube connecting the lower ends of the two columns.

In such an arrangement, circulation of the water in the sense of particles of water completing the circuit would be unknown; on the other hand, however, the "head" producing water movement would be a maximum.

Fig. 81 shows such an arrangement where, instead of the tube connecting the columns being straight, it is bent in order to save space and fall in with practical designs. It will be seen that the gases and water flow in opposite directions, the steam end of the tube being exposed directly to the furnace temperature. Obviously, these lower pipes will, under certain conditions, contain only steam, and the material of which the pipes are made will attain higher temperatures than is considered desirable for safety in practical working. This is one of the main reasons why the Belleville boiler, which is of the type shown in the diagram, has been discarded in the Navy.

The types of boiler which have survived, therefore, are those in which the circulation of the water is vigorous and where water is present along with steam in the "risers." In such designs every effort must be made to eliminate all unnecessary resistance to the water flow, and so proportion the channels that the velocity of the water is fairly uniform throughout.

*(To be continued.)*

## NOTES ON ENGINE SEPARATORS.

By EDWARD INGHAM.

IT is a well-known fact that, in any steam plant, the steam passing through the pipes from the boilers to the engines is never quite dry; in other words, it always contains a certain amount of water in suspension, the actual amount depending on the type of the boilers, the efficiency of the pipe covering, etc. The object of a separator is, of course, to remove this water and so prevent it from passing into the engine cylinders, where it might lead to serious trouble.

Separation is usually effected by changing suddenly the direction of flow, and by providing an opposing surface in the path of the rapidly-moving steam and water.

Owing to the fact that the water is so much heavier than the steam, it is not so readily diverted from its path as the steam, but continues to flow onward in the original direction until it meets the opposing surface referred to, when it is deposited and falls down to the bottom of the separator, from which it can be removed as desired, the steam meanwhile passing on, more or less dry, to the engine cylinders.

Separators are made in a great variety of designs, in the great majority of which the principle of action is that already described. In some designs, however, the steam is made to flow between spiral surfaces, and, owing to the centrifugal action thus set up, the water in the steam is flung against the surfaces and deposited thereon.

One of the simplest designs of separator consists of a vertical cylindrical cast-iron vessel provided with a central partition or dividing plate, which divides the upper portion of the vessel into two parts. The inlet branch is cast on the side of the vessel directly opposite the partition. The steam therefore impinges against the opposing plate, on which the water is deposited, dips down and flows under the plate and then rises upwards, finally leaving by the outlet branch, which is directly opposite the inlet branch. The water dips down from the partition, and is intended to fall to the bottom of the vessel, but it will be seen that since the steam flows under the partition, the water will have to fall through

the current, and some of it will in all probability be picked up again and carried into the engine cylinder. For this reason, the design is not a satisfactory one. An improvement might be made by providing the partition with a sort of gutter at the bottom, so that the water could be drained away instead of being allowed to fall into the current.

In all cases, the design should be such that there will be no tendency for the separated water again to become entrained with the steam. Unless this point be carefully observed, the separator cannot be said to be efficient.

Another simple and common design of separator consists of a cylindrical vertical vessel with an internal pipe extending about half-way down. This pipe really constitutes the steam inlet; the outlet is on the side of the vessel, near the top. The wet steam passes down the inlet pipe and then rises upwards to the outlet branch, whilst the water is deposited in the bottom of the vessel, and is not so liable to become again entrained in the steam.

The two designs described in the foregoing are both very simple, but are perhaps not thoroughly effective, more particularly the first one. Better results appear to be obtained when the steam is made to pass through a number of small holes or perforations before it can leave the separator, as in the case of an anti-priming pipe in a boiler. With such an arrangement there is an additional surface for arresting any water which still remains in the steam as the latter is about to leave the separator.

In some designs a complicated arrangement of baffles is provided, the steam being made to travel through long and tortuous passages. The object is, of course, to ensure thorough separation of the water, but it is open to question if these baffles really serve any useful purpose, because experience has shown that the most complete separation may be effected without the employment of any baffles whatever. Further, the introduction of baffles and tortuous passages is bound to interfere more or less seriously with the free flow of the steam, and may cause an appreciable drop in the pressure.

Generally speaking, the separator should be placed as near as possible to the engine. If placed any considerable distance away, so that a long length of steam pipe intervenes between the engine and the separator, the steam may again become wet by condensation by the time it reaches the engine, particularly if the piping is exposed and not efficiently lagged.

In all cases where the steam delivered from the boiler is very wet, and where the distance between the engine and the boiler is considerable, a separator of good design is a necessary adjunct to the plant. Whilst its main object is to remove the water from the steam, it also serves as a steam receiver, and is consequently useful in tending to steady the flow of the steam. It is well known that steam receivers are sometimes placed in close proximity to the engine with the object of preventing vibration of the steam pipes. Such vibration is often caused by pulsations of the steam in motion. These pulsations result from the fact that the engine does not take in the steam continuously, *i.e.*, in a steady flow, but in gulps, as it were. Thus, each stroke of the engine the steam is admitted for a portion of the stroke and then cut off, so that the flow is being repeatedly checked many times a minute, depending on the speed of running of the engine. Since the velocity of flow of the steam in the pipes is very high, these repeated stoppages give rise to pulsations, which in turn give rise to vibration of the pipes. If the natural period of vibration of the pipes and their supports should happen to be the same as that of the pulsations, the pipes may vibrate to a dangerous extent. In any case, the vibration is objectionable, and a remedy should be sought. The obvious course to adopt is to prevent the pulsations of steam, or at least render the flow of steam more regular. Greater regularity may be obtained by making the steam pipes of large diameter, because this reduces the velocity of flow and consequently the effects of the repeated stoppages. The adoption of unduly large pipes, however, means increased expense and greater losses from condensation, and, hence, it may be better to fix a large steam receiver near to the engine. This provides a large reservoir of steam from which the engine can take its supply. The general tendency is thus to prevent momentary fluctuations of pressure and consequently render the pulsations less severe. With a sufficiently large receiver, the pulsations, and consequently vibration of the steam pipes, could, of course, be almost entirely prevented.

Whilst the ordinary separator acts also as a receiver, its capacity is usually so small that it is of little use in this connection. To be of much value, the capacity would generally require to be at least three times that of the high-pressure cylinder, and in many cases considerably more, whereas it is often little more than equal to that of the cylinder.

It will be seen, then, that in cases where steam pipe vibration is likely to be, or is experienced, the question of making the separator of large dimensions is well worth consideration. The efficiency of the vessel as a separator would not be impaired by making the capacity greater; in fact, a large vessel possesses an advantage over a small one, inasmuch as it is better able to cope with large quantities of water should such come over from the range, as sometimes happens when the engineer-in-charge forgets to run off the water which has accumulated in a superheater.

## ROCK ASPHALTE: ITS INDUSTRIAL APPLICATIONS.

By James Vose

(*Continued from page 74.*)

### Lining Tanks.

An application of rock asphalte which, at the moment, is of particularly appreciated service is that of the lining of variously constructed tanks with a view to making them water or acid-tight. When it is desired simply to make the tanks water-tight, the standard rock asphalte as described in the previous article will suffice. When acids have to be retained, it is necessary to employ a special asphalte, as limestone, which forms the aggregate of standard rock asphalte, is, of course, very rapidly attacked by acids. Consequently, various rocks resistant to acids are utilised, but the bitumen which binds the particles together is practically similar to ha used in he non-acid-resisting type. A feature common to both kinds of asphalte is, that although the particles of mineral aggregate, all are very small; those of well-made rock asphalte are as—or more so—scientifically graded (as regards the various-sized meshes through which they will pass, and the proportions of each grade employed) as is aimed at in the highest grade macadam road metal or building and engineering concrete. The care thus exercised is given with the object of ensuring the more perfect interlocking of the particles, and the production of a dense body and smooth surface finish. Given these

attributes, the obtaining of satisfactory linings for tanks or coatings for roofs, walls, etc., is greatly facilitated.

### Details of Application: Brick Tanks.

Sundry variations are met with when applying rock asphalte to tanks and analagous requirements. Tanks constructed of brick, stone, wood, concrete, or—in certain cases—iron, may effectually be dealt with. In the case of brick tanks, in order to form a key for the asphalte, the mortar in the joints of the brickwork is raked out to a depth of about ⅝ in. or ¾ in. The bottom of the tank needs no preparation.

### Stone Tanks.

Stone tanks usually have the sides prepared to receive the asphalte by a number of holes being drilled and plugged with wood, which enables a layer of special mesh expanded metal to be secured to the walls. The expanded metal is carried down to and overlaps the bottom by several inches. A suitable key thus is provided for the asphalte. As in the case of the brick tanks, no special preparation of the bottom is needed.

### Concrete Tanks.

In concrete tanks the procedure varies a little in accordance with the particular finish which may have been left on the tank sides, and the depth of the tanks. Sometimes "hacking" or suitable roughening of the concrete will answer the purpose of keying requirements; in other instances it is necessary to secure expanded metal as in the stone tanks. On the bottom the asphalte is laid direct as in the case of the brick and stone ones.

### Wood Tanks.

When wood tanks are to be made water-tight or acid-proof, the securing of expanded metal to the sides is requisite in practically all cases, it being carried down to, and overlapping, the bottom somewhat. First of all, though, a layer of special felt, such as is used by slaters for roofs of buildings, is firmly secured to bottom of tank. This assists in absorbing any vibration and ensuring proper adherence of the asphalte.

### Iron Tanks.

It is possible to line iron tanks with asphalte of either the non-acid-resisting or acid-proof types, but unless special arrangements are made, it is more costly. The drilling of the holes to secure expanded metal to the sides is more expensive than in the case of the stone or concrete tanks. However, it would be possible, in the case of tanks being newly built with a special view to their holding acids, to have suitable projections cast on or otherwise provided in order to form the necessary key. The asphalte is laid on the bottom direct.

### Parapets.

In many of the instances where it is decided to employ asphalte as a tank or flat-roof lining, it is advisable to carry the asphalte right over the top edges, as there is always liability to splashing of water or acids, with consequent eventual trouble, or sometimes a capillary action takes place which has the same effect. Or, in the case of the flat-roof tanks, into which the flat roofs of modern cotton mills often are built, the action of the wind often causes waves and splashing which wets and goes over the parapet and causes the walls to be made damp from the outside. The carrying up of the asphalte under the coping stones averts this objection.

Another precaution it is sometimes advisable to take is the provision of a wood sill round the top edges of tanks to prevent damage to the asphalte due to the bumping of buckets or materials being deposited in the tanks. This particularly applies at the present time to the matter of "nitrate cake" storage at bleach and dye-works, paper mills, etc. At these works sulphuric acid is being obtained by dissolving the "nitrate cake," which formerly was considered a practically worthless by-product of some other process, but now is found to contain up to 30 per cent of sulphuric acid which can more or less advantageously be utilised. The former sources of supply of acid now mainly have their product absorbed for the production of high explosives. The nitre cake, being in lumps, something like hard-frozen snow, could, when roughly placed on the tank edges, easily damage the asphalte. The renewable wood sills thus are indicated.

### Thickness of Asphalte: Fillets.

Usually it is best to make the asphalte at the bottom of tanks thicker than at the sides, to allow for any accidental or careless dropping of material such as nitre cake, which might tend to crack the asphalte in places. The thickness at bottom therefore should not be less than, but distinctly more than 1 in. thick. The average thickness of the asphalte on sides is about ¾ in. In each of these cases the asphalte is laid in two or more separate coats with fused, overlapping joints, and at the junctions of the flat and vertical work, and at the verticle angles, strong fillets of asphalte are laid in two double-fused coats, this procedure greatly strengthening the entire asphalte construction.

### Repairing Stone Steps.

Other particularly valuable applications of rock asphalte include the rapid and effectual repair of stone steps and landings of mills, etc., and the reinstatement of wood stairs in suitable instances, with the minimum of disturbance to regular routine. As in the preceding paragraph, the methods here outlined represent the up-to-date practice of Messrs. John Dickinson and Co. (Bolton) Ltd., of Fairclough Street, Bolton.

It will be well known to *Industrial Engineer* readers that constantly-used stone steps wear into deep ruts at certain well-defined places, and that the dressing of the steps by masons is only a temporary palliative, as, in the ordinary way, the steps must either have stone slabs dovetailed in at considerable expense and delay, or have the steps turned over and dressed, which again is unsatisfactory and costly.

The method adopted by Messrs. Dickinson is to secure to the front edge of the treads a length of convex iron of suitable breadth and thickness for each case. These iron strips are let into the walls of staircases, about 2 in. at each end, and are further firmly secured to the steps by two or three prongs screwed and riveted into the strips, the projecting portion of the prongs having turned-down ends about an inch long which are inserted into holes drilled in the stone treads.

The convex iron is so placed that its top edge projects above the original level of steps to the extent of the thickness of asphalte to be employed. It prevents the asphalte being forced away from the step edges by the outward and downward pressure of the traffic. The cooked rock asphalte, which is "armoured" by the admixture of dry, clean crushed granite, then is spread level with the top edge of the convex iron, and—its lower contour following that of the worn top of steps—it automatically has an appropriately increased thickness where

most required to resist the regular duty, and, whilst quite level at the new tread surface, is comparatively thin at the places where practically no wear is experienced.

### Repairing Wood Stairs; Hoist Landings.

Wood stairs and hoist landings are dealt with on somewhat similar lines, but with variations found necessary in individual instances. When repairing wood stairs, any vibration due to long use should be remedied by strengthening the treads with wood cleats on the underside, etc. Cast-iron nosings of shape required in each instance, and projecting the requisite distance above the worn treads, then are secured to the stairs by lugs and wood screws, the lugs resting on the risers and treads. Previous to laying the asphalte a layer of felt is secured to the wood treads, absorbing vibration and securing proper adhesion of the asphalte.

In the case of hoist landings, either convex iron or angle or channel iron are used as nosings. Each case is treated on its merits, but, generally, it may be said that rock asphalte is peculiarly in place for this duty, as the wear due to the constant bumping of trolley wheels and frequent foot traffic is very severe and difficult otherwise at all satisfactorily to provide against.

There are other applications of rock asphalte of interest to industrial engineers, and these may be considered in a subsequent article.

## NEW MACHINERY AND PLANT EMPLOYED IN SOUTH AFRICAN MINES IN 1915.

According to the Report for 1915 of the South African Mining Engineer, new machinery and plant introduced into mines in the Union during the year 1915 amounted in value to £606,682 (including diggers and works £9,907) the chief items, being as follows:—

Transvaal.

| | Gold Mines. | Coal Mines. | Base Mineral Mines. |
|---|---|---|---|
| | £ | £ | £ |
| Boiler plant (other than that of locomotives, traction engines, or steam wagons) | 4,982 | 2,076 | 290 |
| Headgear | 7,520 | 2,608 | — |
| Steam engines for winding | 8,209 | 1,875 | 255 |
| Steam engines for compressors (including compressors) | 3,874 | 2,036 | — |
| Pumps | 28,740 | 2,876 | 1,164 |
| Steam locomotives | 5,725 | 6,656 | — |
| Reduction plant | 64,315 | — | 6,486 |
| Washing plant | — | 7,012 | — |
| Treatment plant | 16,548 | — | 706 |
| Workshop plant | 15,551 | 637 | 111 |
| Electric generators and engines, hoists, locomotives, and motors | 85,411 | 4,099 | 633 |
| Power lines, transformers, bells, telephones, etc | 78,642 | 1,333 | 205 |

The most important items comprise stamp mills and tube mills for the new mines on the Eastern Rand, winding plants for these mines, electric winders for other mines, and increases in the electrical plant at central power stations.

As regards the other Provinces of the Union, new power lines, transformers, bells, telephones, etc., to the value of £11,223 were introduced into diamond mines in Cape Province during the year, and boiler plant, steam engines for compressors, and washing plant to the value of £9,940 into Natal Province.

The above-mentioned report, containing detailed particulars and statistics regarding the various types of machinery and plant in use in mines in the Union in 1915, may be consulted by British firms interested at the Department of Commercial Intelligence, 73, Basinghall Street, London, E.C.

## INSTALLING AKERLUND GAS PRODUCERS AT RICHMOND WORKS OF AMERICAN LOCOMOTIVE CO.

Three No. 50, Type "B," Akerlund gas producers, each rated at 500 H.P., with an overload capacity of 20 per cent. for gasifying bituminous coal and operating in conjunction with a 1,000-kilowatt Westinghouse engine, are being installed at the American Locomotive Co.'s Richmond plant by the Standard Gas Power Co., 17, Battery Place, New York, and 713, Grand Building, Atlanta.

Due to the mammoth dimensions of each of the three generators, special arrangements have been made for the transportation of the vaporiser and water-cooled top, while the shells will be shipped knocked down.

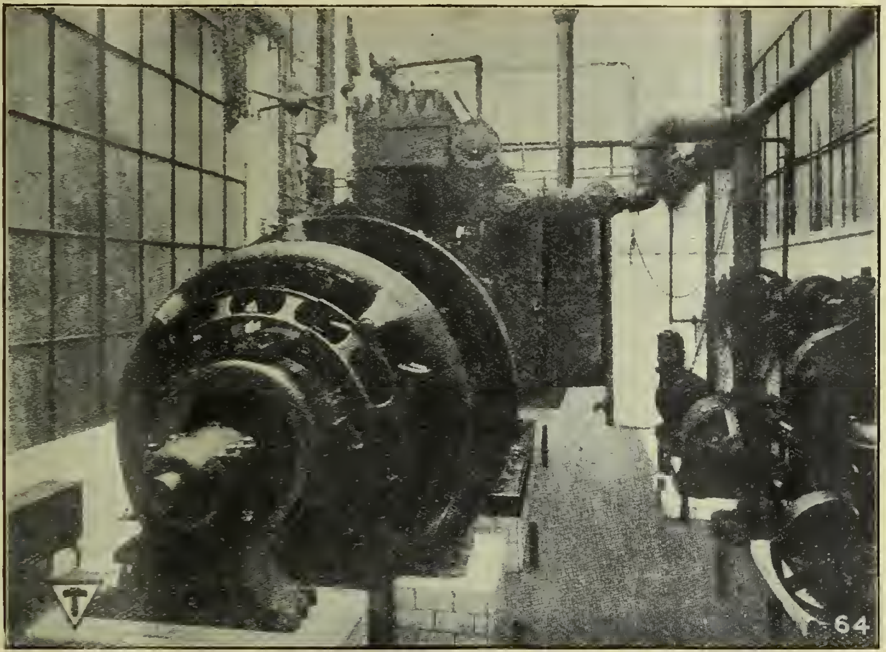
The ability of the Akerlund system, says the "Manufacturers' Record," to gasify bituminous coals, as well as other bituminous fuels, such as wood, charcoal and coke, lignite, mixture of bagasse and molasses, bagasse, peat, etc., is claimed to be due to the down-draught principle, in which the tarry impurities, upon distillation, are forced through the incandescent fuel bed, when they are said to be converted into stable gases for power and fuel.

The Akerlund bituminous gas producer, built by the Standard Gas Power Co., is of the single-zone, suction, down-draught type. The system, which is illustrated in the accompanying sectional view, comprises a generator, in which air saturated with water vapour is drawn downward through the incandescent fuel effecting the necessary combination of gases; a cooler in which the gas is washed and cooled by sprays of water; a stationary scrubber in which the process of cleansing is carried still further; a combination purifier and pressure-regulating tank, containing wood shavings, sawdust or other purifying material arranged on a series of perforated trays, in which the gas is freed from all moisture and impurities which may have passed through the rest of the system. Suction is maintained by a slow-speed, light-running, positive exhauster. The exhauster discharges through the small pressure-equalising tank. An automatic pressure-regulating valve, with a bye-pass connection, relieves the fire from excessive draught when the load varies, and makes the draught through the fire at all times proportional to the load. There is provision, also, for using the exhauster to blow the fire up-draught when starting from dormant conditions, and for reversing the draught to deliver gas to the engine or furnace by manipulating valves and without changing the direction of rotation or drive of the exhauster. All inspection and cleaning doors are held on by clamps and hand screws, so the entire system can be opened for inspection and closed without the use of a wrench.

The gas generator is a steel shell, including an annular vaporiser somewhat below the fire line. The shell is supported on piers in a water pit. In the centre of the pit, extending upward inside the space enclosed by the shell and to a point somewhat below the vaporiser, is a conical ash pier to prevent irregular accumulation of clinkers and to divert ashes outward for easy removal. The outer wall of the vaporiser and the inside wall of the shell, in connection with the horizontal baffle-plate extending half-way around, form a gas accumulation chamber for insuring uniform distribution of draught over the entire fuel bed by taking off gas in an annular current which circulates in a horizontal plane outward from the centre to both inlets of the accumulation chamber. Air is introduced above the surface of water in the vaporiser downward through

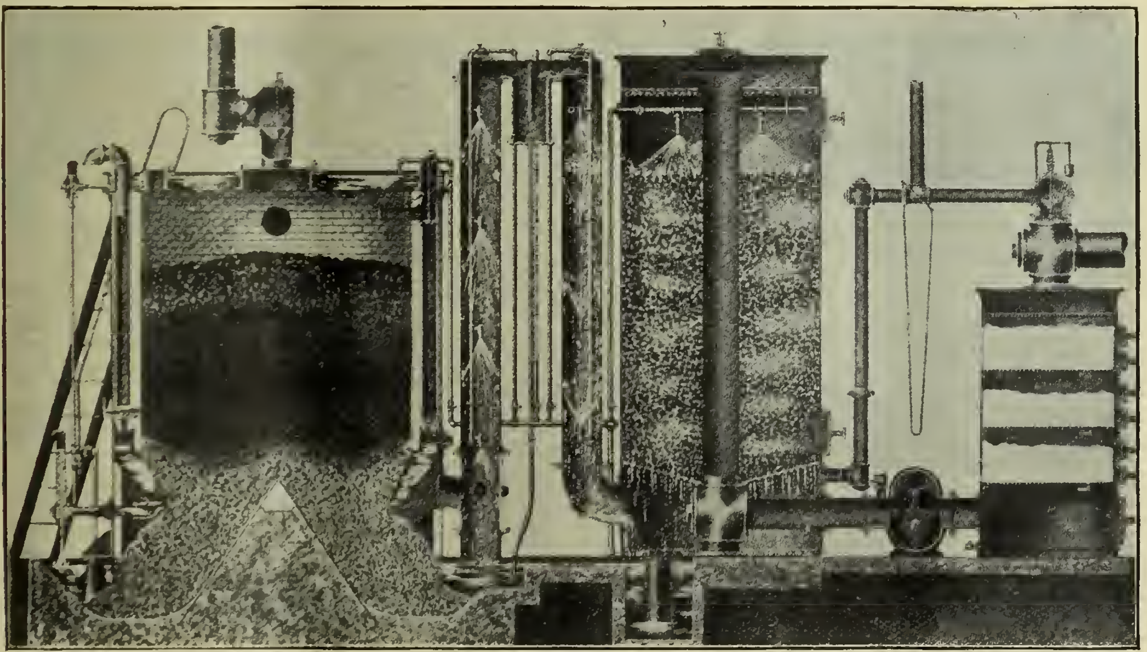
induction pipes. By circulating over the warm water in the vaporiser the air takes up a certain amount of vapour; the mixture of air and vapour then goes upward through similar fire this mixture of air and vapour supports the chemical rections characteristic of the formation of producer gas.

The vaporiser acts as a support for a single cylindrical




A Complete Type "B" Producer-Gas Electric Power Plant. The Producer is seen in the Background.

pipes, and is released immediately above the fuel bed in the combustion chamber. Since the vaporiser is maintained automatically at a constant temperature by a thermostat, and since the draught through the generator is automatically regulated by the demand of gas, the air and vapour supplied to the fire is said to be maintained in constant and correct proportion. In its passage downward through the lining of standard firebrick. The fire is supported on the ashes which build up from the bottom of the pit, there being in the generator no grates or slopes which could form a lodging-place for ashes or clinkers, and thereby cause irregularities in the fire, which would lead to a variation in the quality as well as in the quantity of gas delivered. The walls of the vaporiser are exposed only to ashes and



Sectional Elevation of the Akerlund Type "B" Gas Producer.

hot gas, the fire being well above. All joints in the vaporiser are water-protected, and the heating surface is well below the water level. The top of the generator is provided with charging doors arranged conveniently for charging fuel, poking, and inspecting the fire. Ashes are removed through the water-seal bottom.

The cooler consists of two or more legs of iron pipe, mounted vertically and containing sprays, connected by a water-seal valve. Gas from the accumulation chamber passes upward through the first leg, thence through the connecting valve and downward through the second leg to the stationary scrubber. In the cooler the gas is sprayed with cool water; impurities are washed out continuously through the large direct water-sealed drains. The valve is wide open during operation, being sealed by a continuous supply of water, only during dormant periods to cut off the generator from the rest of the system.

The scrubber is of the usual cylindrical form, with a cast-iron grate supporting a bed of coke, crushed stone or brickbats. Gas entering below the grate in its upward passage meets finely-divided water from the sprays above. The gas then goes downward through an outlet pipe mounted in the centre of the scrubber, and is further cooled by radiation. As in the cooler, sprays are designed for easy removal and inspection. The scrubber top is removable, and large inspection doors are provided.

The combined purifier and expansion tank is a cylinder, usually about 4 ft. by 8 ft., connected on the discharge side of the exhauster. It contains several perforated trays supporting sawdust or other purifying material which absorbs moisture and suspended matter, being valuable also as an indicator of the cleanliness of the gas.

The function of the exhauster is to create draft through the system. The Akerlund producer runs at low suction, rendering unnecessary a high-power exhauster.

A regulating system to insure even pressure on the line is formed by a bye-pass regulating valve of the poppet type.

The company manufactures type "M-B" producers, which are similar in principle to type "B," but they are designed for mechanical operation throughout in units of 1,000 horse-power, having automatic feed, stirrers and ash disposal features In the latest type "B" and "A" producers, instead of having induction pipes in the brick-lining, as shown in the elevation, they are designed with induction pipes extending from vaporiser to point of admission, outside of the shell.

## SPRAYING CONDENSING WATER.

By Norman E. Horn.

Steam engineering has one important exception to the general rule that heat must be conserved wherever possible, and it is necessary because of the problem arising from the presence of the latent heat in steam that has been expanded to low pressure. It is mechanically impossible directly to convert this latent heat into power. To approximate the highest possible efficiency in the engine, it is necessary to create a vacuum by condensing the exhaust steam, when the latent heat of the steam must be dissipated.

How to get rid of this heat, amounting to 970 B.Th.U. per pound of condensed steam, economically is a problem almost as important as conserving it prior to the steam being exhausted from the engine.

Circulating cooling water through a condenser to absorb the heat is the only practical method. But often where a large supply, such as a lake or a river, is not available, repeated use of the cooling water is necessary. The heat transferred from the steam to the water must be removed so that the water will be cooled enough when re-circulated to maintain a satisfactory vacuum in the condenser. The available medium to which the heat may be transferred is the atmosphere.

The problem, therefore, resolves itself into this: How can heat in a quantity of water be transferred to the air at least expense and with reliability? When the latent heat of the steam is extracted in the process of condensing, about 970 B.Th.U. per pound of condensate is absorbed—enough heat to raise the temperature of nearly 970 lbs. of cooling water one degree—barring some small loss from radiation.

To operate efficiently, cooling water should be at least 22 deg. cooler than the steam in the condenser. This would give a ratio of cooling water to condensed steam of 970 to 22, or, roughly, 44 to 1. In actual practice a slight margin is allowed, making the ratio about 50 or 60 to 1, depending on many conditions, such as the vacuum desired, average humidity, temperature conditions, and the use in connection with reciprocating engines or turbines.

The condensing water on coming from the condenser has a temperature 20 deg. to 22 deg. higher than it can have when it is returned. The atmosphere that must absorb this heat from the water can receive it in three ways—by convection, by radiation, and by evaporation. This last may be considered as a heat transfer to the atmosphere, although, strictly speaking, the heat absorbed by evaporation becomes latent heat in the vapour evaporated.

Each of these operations is accelerated by increasing the relative area of the water exposed per unit of volume—that is, evaporation, radiation, or convection will occur more rapidly if the exposed area of a given volume of water be increased.

The solution of this problem by the cooling-pond method is to employ a system of pipes and nozzles through which the water is pumped and sprayed into the pond. To understand why spraying is effective in cooling water, assume that the water in the pipes is a series of globules of water, each the diameter of the inside of the pipe. As these units reach the nozzle they are whirled apart and scattered into a number of smaller globules, which, by the action of the air in retarding their velocity after they are thrown from the nozzle, are again divided into still smaller units.

The small particles of the spray freely permit the passage of currents drawn in on all sides up through the spray, cooling it by contact or convection, by radiation, and by evaporation. The spray falling back into the pond is cooled enough to be pumped back to the condenser. The action of the sprays induces rapid currents of air to pass up through them.

While it is true that a continued increase in sub-divisions would result in a greater increase in heat transferred, there is a point beyond which it is not advisable to go. The reason is that as the particles decrease in size they are supported longer in the air, and any considerable amount of wind might cause them to fall outside the limits of the pond. This loss, known as "drift loss," is in a well-designed pond practically negligible. Engineers specialising in this subject have determined the grade or weight of sprays which give most practical results, and have found that a properly designed system increases the capacity of a natural pond about 35 times. The heat in the water is rapidly absorbed by the surrounding air, and in addition the evaporation of a certain amount of water lowers the temperature of the remainder considerably—often several degrees lower than the air.

The cooling action of the spray system is not seriously affected by humidity conditions, because the supply of air is so tremendous and the contact is so brief that the slightest capacity of the air to pick up moisture results in sufficient evaporation.

The spray method has several practical advantages. The first is that a spray cooling pond is comparatively low in cost, and with suitable piping and nozzles there is practically no depreciation or upkeep. In normal operation the cost of operation is low. In cool weather the spray system can be operated at very low pressures.

An important feature in connection with the system is the design of the nozzles used to break up the water. It is necessary that a nozzle be used that will sufficiently atomise the water, but to keep operating cost down it is desirable that the nozzle be so constructed as to give the desired spray effect with the least possible pressure.—*Power*.

# Trade Items, Notes, &c.

The New South Wales Government have decided to construct a concrete and masonry dam across the Cordeaux River in connection with the Sydney water supply system.

The analysis of a stainless steel given in a French technical journal is: Carbon, 0·28 per cent; silicon, 0·01 per cent; manganese, 0·12 per cent; chromium, 12·7 per cent; cobalt, 0.45 per cent; iron, 86·6 per cent.

The Minister of Munitions has made further orders under the Munitions of War Acts, 1915 and 1916, under which 129 additional establishments have been declared controlled establishments. The number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 4,512.

Charging Blast Furnaces. A licence has been granted to Messrs. Newton, Chambers and Co. Limited, Sheffield, to manufacture furnace hoists and charging mechanism for blast furnaces, with opening and closing devices for the mouths of furnaces, under three patents, two of which were owned by the J. Pohleg Aktien-Gesellschaft, and the other by Aumund.

Wireless in Holland.—*Het Volk* learns that a Dutch company is being formed with the support of various big shipowners for the manufacture and delivery of apparatus for wireless installations on board Dutch and other ships with a view to being independent of the British Marconi Company and the German Telefunken Company.

British-made Magnetos.—According to the *Commercial Motor* all-British magnetos are now being made at the rate of, approximately, 2,000 machines per week, and practically the whole of this production is being utilised for Government work. These home-produced magnetos are being made equal in merit to the Bosch, and in some particulars even better.

The linking-up of the generating stations of the various electric works in the Metropolis is expected to economise enormously the cost of production, and to save some thousands of tons of coal annually, in addition to the different stations being able to assist each other in dealing with the heavy demands for current and continue the working where partial breakdowns have taken place.

Telegraph, etc., Rates in France.—The Budget Commission of the French Government has decided to raise the postal, telegraph, and telephone rates. It is estimated that the additional receipts will amount to £2,400,000 sterling. The rates for letters will be 1½d., 2d., and 3d., according to weight. Telegrams up of 50 words will pay a supertax of 2½d., and above 50 words 5d. The pneumatic post rates will be 4d. and 7½d. Telephones: Private, £18 yearly, instead of £16; service flats, £20; cafés, hotels, etc., £32.

South Wales Coal Mines Control.—Under the Defence of the Realm Act, the Board of Trade have made the following Order: "Regulation 9 G. of the Defence of the Realm (Consolidation) Regulations, 1914, is hereby applied, as from the first day of December, 1916, until further notice, to the South Wales coalfields—that is to say, to all coal mines in the counties of Brecon, Carmarthen, Glamorgan, Monmouth, Pembroke, and Radnor." In pursuance of this Order, the Board of Trade have directed the colliery firms and companies affected by the Order to carry on as usual, subject to any further instructions. The President of the Board of Trade has appointed an Inter-Departmental Committee, representing the Board, the Home Office, and the Admiralty, to advise with regard to the directions to be given under the new Order. The Committee will meet forthwith to deal with outstanding questions as to the general rate of wages in the South Wales coalfields.

Diesel Engine Users.—At the November meeting of the Diesel Engine Users' Association several new members were elected, and a long list of consulting engineers, manufacturing firms, and others interested in Diesel engine work, but not qualified for full membership, was accepted as "subscribers" to the association. This new class of "subscribers" is entitled to receive copies of the reports and proceedings and other information and particulars circulated by the association. The president, Mr. Geoffry Porter, announced that the committee's report on "Air Compressor Explosions and Troubles," with their recommendations on the subject, had been finally revised, and that it would be printed and circulated to the members and subscribers. The hon. secretary gave particulars concerning several types of distance thermometers for use on air compressors. Mr. George B. Vickers read a paper on "Piston and Small End Lubrication in Diesel Engines."

A self-lubricating metal is reported to have been produced in America in which the mechanical strength of graphite is increased by impregnating it with a metal. The mixture is called "Graph-alloy," and is not injured by contact with oil; in fact, oil can be used along with it. The graphite is placed in a crucible of the same material, together with the molten metal with which it is to be impregnated. The crucible is then placed in the cylinder of a large press, and a partial vacuum created simultaneously with the application of heat. Upon the completion of this operation high-pressure air is admitted to the cylinder of the press. The plunger of the press on which rests the crucible is also forced up by hydraulic pressure. After impregnation the graphite is found to have absorbed metal enough to increase its original weight by 150 per cent. For bearing purposes the alloy used is babbitt.

Definition of "Motor Spirit."—The Commercial Motor Users' Association has been successful in obtaining an official interpretation of the meaning of the term "motor spirit," over which interpretation there has been so much controversy since the issuing of the Order in Council of August 18th last. After lengthy correspondence with several Government Departments on the subject, an official communication was forwarded by the association to the Home Office strongly representing to the Home Secretary "the expediency of the issuing of an immediate instruction to chief constables throughout the country to allow no prosecutions to be instituted under the Order in Council of August 18th unless the fuel in question pays the petrol tax." The association has been officially informed by the Home Office that, after consultation with the Board of Customs and the Board of Trade, the Secretary of State has made a suggestion to the police forces on the lines suggested. The C.M.U.A. defended an action against one of its members at Pontefract for using shale oil and paraffin, and in view of the intimation received by the police from the Home Office referred to the prosecution withdrew the case.

## NEW COMPANY REGISTERED

LIGHT RAILWAYS LTD. (145,152).—Private company. Registered October 25th. Capital, £50,000, £1 shares. Objects: To manufacture and contract for the supply, delivery, and carriage of, and to erect, maintain, repair, and work any material, machinery, plant, permanent way, rolling, or other stock or tools required for or used in connection with any means, method, or system of locomotion, transport, traction, or communication, whether the same is now known or may be hereafter discovered or invented, and to supply power and the means of producing and transmitting same. Directors: M. Sharpe, J.P., A. T. Clay, M. Horner, J. S. Horner, A. Hoare, and A. G. Birch. Qualification, £500. Secretary (*pro tem.*): J. H. Greene. Registered office: 2, London Wall Buildings, E.C.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS

**October 30th to November 18th (inclusive).**

Albion Motor Car Co.: Friction clutches. 15,713.
Allen, V. M. Commutators. 15,597
Alvord, J. F.: Igniters. 15,464.
Anderton, A.: Clutches. 15,486.
Anderton, W. R.: Clutches. 15,486.
Armstrong, Whitworth, & Co., Sir W. G.: Pipe, &c., connections. 15,796.
Ashford, J.: Reciprocating pumps. 15,462.
Axilrod, M.: Clutch and brake mechanism. 15,524.
Alley, S. E.: Differential gear. 15,912.
Anderson, W. J.: Utilising effective motive-power of exhaust of internal-combustion engines. 15,995.
Adams, C.: Rotary engines. 16,529.
Adams, C. H. and S. H.: Pumping-plant. 16,476.
Baumann, K.: Axial-flow steam turbines. 15,521.
Baumann, K.: Steam turbines. 15,522, 15,523.
Bayliss, T. P.: Joints in steam pipes. 15,528.
Beeby, A. R.: Internal-combustion engines. 15,540.
Berriman, A. E.: Internal-combustion engines. 15,584, 15,586.
Berriman, A. E.: Cylinders. 15,793.
Berriman, A. E.: Carburettors. 15,798, 15,799, 15,809, 15,810, 15,811.
Berriman, A. E.: Carburettors. 15,812.
Board, G. W.: Steam, &c., turbine. 15,451.
British Ever Ready Co.: Dry batteries. 15,546.
British Thomson-Houston Co.: Blanks for gear-wheels. 15,744.
Buckingham, W. H.: Worm drive. 15,549.
Buckingham, W. H.: Railway truck, and drive therefor. 15,550.
Burwell, W.: Liquid-level gauges. 15,672.
Beaty, R. J. H.: Pumping-rams of multiplex-ram pumping-installation. 16,055.
Berriman, A. E.: Ignition plugs. 15,934.
Berriman, A. E.: Carburettors. 15,949, 15,950, 15, 51.
Berriman, A. E.: Carburettors. 16,079.
Berriman, A. E.: Cylinders for engines. 16,188.
Beswick, H. J.: Internal-combustion engines. 15,817.
Boulton, A. H. and J. H.: Ignition magnetos. 16,155.
Bray, Markham, & Reiss, and Bray, E. N.: Pumps. 16,023.
Brewster, J. M.: Internal-combustion engines. 15,913.
Baguley, C.: Steam-raising plants and heat engines. 16,570.
Baradat, C.: Internal-combustion engines. 16,387.
Baumann, K.: Steam turbines. 16,296.
Beddard, E. B.: Ball-bearing extractor. 16,477.
Belyavin, P.: Scavenging cylinders of internal-combustion engines. 16,458.
Birkbeck, H.: Sparking-plugs. 16,521.
Bowler, J.: Stop-motions for knitting-machines. 16,404.
British Thomson-Houston Co.: Regulating-mechanism for controlling speed of induction motors. 16,250.
British Thomson-Houston Co.: Centrifugal compressors. 16,516.
Burgess, F. T.: Pistons. 16,549.
Christofferson, S.: Engine jacket and cylinder. 15,603.
Cleathero, T. H.: Differential gear. 15,600.
Cleaver, H. C.: Mechanical transmission of power. 15,751.
Cleaver, R. L.: Dynamo-electric machines. 15,500.
Cooper, F. W.: Valve mechanism. 15,575.
Cotelle, J.: Apparatus for raising liquids. 15,467.
Climax Rock Drill and Engineering Works: Valve-gear. 16,203.
Cockburn, D.: Steam valves. 15,998.
Contin, A.: Supplying feed-water. 16,150.
Cook, D.: Motive-power engine. 15,919.
Cooke, G. F.: Magneto-electric machines. 15,901.
Cooke, G. F.: Magneto-electric machines. 16,144.
Cortesi, C.: Supplying feed-water, &c., to steam-generators, &c. 16,150.
Crowe, J.: Mechanical drive-belts. 16,103.
Carey, R. F.: Hydraulic pumps. 16,381.
Clark, W. A.: Sparking-plugs. 16,215.
Cook, S. S.: Gear trains. 16,422.
Cowey, L. E.: Gauges. 16,447.
Cracknell, T.: Safety valve. 16,488.
Cummins, W. R.: Internal-combustion engines. 16,267.
Daimler Co.: Internal-combustion engines. 15,584.
Daimler Co.: Internal-combustion engines. 15,793.
Dix, S. G.: Plug-cocks, valves, &c. 15,663.
Dobson, J.: Pivotal bearings. 15,639.
Daimler Co.: Ignition plugs. 15,934.
Daimler Co.: Cylinders. 16,188.
Deam, J.: Packing-rings. 16,046.
Dicker, S. G. S.: Carburettors. 16,151.
Dix, S. G.: Plug-cocks. 16,024.
Downs, A., A. W., and H. V.: Valveless and crankless internal-combustion two-stroke engine. 15,828.
Dupont, C. V.: Supplying fuel to engines. 15,879.
Dean, P. P.: Driving-mechanism for valves, &c. 16,418.
Dehn, F. B.: Dynamic balancing-machines. 16,523.
Dynamic Balancing Machine Co: Dynamic balancing-machines. 16,523.
Easty, A. H.: Motive-power generator. 15,948.
Fagard, J.: Carburettors. 15,772, 15,776.
Frost, C. R. B.: Cooling piston-rods. 15,498.
Ford, A. P.: Joint or coupling for rods, &c. 16,421.
Gaymer, J. H.: Fluid-pressure relief valves. 15,725.
General Electric Co.: Fluid-flow meters. 15,526.
General Electric Co.: Blanks for gear-wheels, &c. 15,744.
Giesserei und Maschinenfabrik Oggersheim P. Schutze & Co. Akt.-Ges.: Centrifugal pumps. 15,726.
Gralla, J.: Driving-gear for compressors. 15,832.
Gray, J. W.: Self-holding friction-clutch mechanism. 16,051.
Gaisman, H. J.: Internal-combustion engines. 16,455.
General Electric Co.: Regulating-mechanism for controlling speed of induction motors. 16,250.
General Electric Co.: Centrifugal compressors. 16,516.
Hardacre, F.: Carburettors. 15,646.
Houghton, S. A.: Water-tube boilers. 15,589.
Hartnell, G. T.: Liquid-fuel vaporiser. 15,890.
Heenan & Froude: Internal-combustion engines. 16,122.
Hoersting, W. A. H.: Internal-combustion engines. 16,004.
Hopkins, L. S.: Constant-speed driving-device. 16,087.
Heelam, B. J.: Variable-speed hydraulic power-transmission apparatus. 16,548.
Humber Ltd.: Pistons. 16,549.
Hutchinson, E.: Carburettors. 16,240.
Innes, F. O.: Hot-air or gas turbine. 15,823.
Inshaw, G. R.: Rotary internal-combustion engines. 16,205.
Inshaw Rotary Engine Syndicate: Rotary internal-combustion engines. 16,205.
Jack, H. W. T.: Combined clutches and gears. 15,457.
Jackson, W.: Internal-combustion engines. 15,476.
Jacobsen, R. S.: Operating reciprocating conveyers or screens. 15,595.
Jaeger, E.: Revolution-counter. 15,535.
Koressios, T. N. C.: Internal-combustion engines. 15,774.
Kayser, C. W.: Heating furnaces. 16,550.
Kayser, Ellison, & Co.: Heating-furnaces. 16,550.
Leach, R. W.: Plug-cocks, valves, &c. 15,663.
Lindsay, R.: Variable-speed gears. 15,790.
Leach, R. W.: Plug-cocks. 16,024.
Lewis, W.: Steam-superheaters. 16,289.
Lleo, A.: Internal-combustion engines. 16,387.
London Electric Supply Corporation: Furnaces. 16,515.
Longford, H. G. and W. W.: Sparking-plugs. 16,215.
Markham, J.: Joints in steam pipes. 15,528.
Marks, E. C. R.: Reciprocating pumps. 15,462.
Metcalfe, J., J. C., and R. D.: Ejectors. 15,786.
Midgley, A. H.: Dynamo-electric machines. 15,742.
Milner, H. L.: Internal-combustion engines. 15,540.
Morison, D. B.: Steam-condensing plant. 15,783.
Murphy, S. J.: Pistons and piston rings. 15,795.
Murray, T. B.: Friction clutches. 15,713.
Myers, R. P.: Liquid-level gauges. 15,672.
McCallum, T. R.: Loose-ring bearing. 15,883.
MacNicoll, D.: Steam valves. 15,998.
Maddock, F. L. and W. E.: Internal-combustion engines. 16,014, 16,018.
Miles, R.: Power engines or motors. 15,925.
Morrison, W.: Power transmission. 16,083.
Morrison, W.: Starter mechanism. 16,084.
Morrison, W.: Power systems. 16,085.
Morton, H. E.: Vacuum-breakers for condensing steam-engines. 15,940, 15,941.
Machin, S.: Rotary engines. 16,529.
Mason, C. T.: Ignition dynamos. 16,512, 16,513, 16,514, 16,518.
Mitchell, J. L.: Exhausting waste gases from internal-combustion engines. 16,341.
Mudler, F.: Hydraulic power-transmission mechanism. 16,378.
Napier & Son, D.: Internal-combustion engines. 16,409.
Napier & Son, D., and M. S.: Cylinders for internal-combustion engines. 16,410.
Olson, C. B.: Carbon-removers for engines. 15,539.
Oakley, A. E.: Carburettors. 16,031.
Ogden, R. D.: Carburettors. 16,040.
Pooley & Son, H.: Pivotal bearings. 15,639.
Price, W.: Hook couplings, &c. 15,632.
Pitt, J. D.: Reversing multi-cylinder engines. 15,972.
Prassone, E.: Supplying feed-water, &c., to steam-generators, &c. 16,150.
Pullinger, T. C. W.: Sparking-plugs. 16,159.
Parsons, Sir C. A.: Gear trains. 16,422.
Passey, H. G. S.: Internal-combustion engines. 16,368.
Platt, P.: Exhausting waste gases from internal-combustion engines. 16,341.
Ramsay, A.: Valves of internal-combustion engines. 15,752.
Read, W. J.: Variable-speed gear. 15,444.
Read, W. J.: Internal-combustion engines. 15,445.
Remington, A. A.: Returning oil from bearings of internal-combustion engines. 15,645.
Rackham, J.: Internal-combustion engines. 16,122.
Ram, F. R.: Supplying fuel to internal-combustion engines. 15,879.
Rignold, H.: Internal-combustion engines. 16,039.
Ramsay, A. J.: Shaft bearings. 16,316.
Reading, H. C.: Internal-combustion engines. 16,239.
Roperton, C. G.: Scavenging cylinders of internal-combustion engines. 16,458.
Robinson & Son, T., and C. J.: Driving-belts. 16543.
Rowledge, A. J.: Internal-combustion engines. 16,409.
Sandycroft Ltd.: Dynamo-electric machines. 15,500.
Schueler, G. R.: Pumping, exhausting, and blowing 15,559.
Slack, J. E.: Clutches. 15,697.
Smith, T. H.: Spindles for spinning, &c., machines. 15,703.
Strong, R.: Carburettors. 15,654.
St. Stephens, R. de H.: Valve gear. 16,203.
Sankey & Sons, J.: Starting engines of petrol-electric vehicles, &c. 16,032.
Soc. J. & A. Niclausse: Feed-water regulator for boilers. 15,863.
Stromberg Motor Devices Co.: Internal-combustion engines. 16,151.
Saurer, A. (Firm of): Braking explosion motors. 16,573.
Soc. Clerget, Blin, et Cie: Sparking-plugs. 16,248.
Speed, J. A.: Carburettors. 16,317.
Sphinx Manufacturing Co.: Sparking-plugs. 16,215.
Submersible & J.-L. Motors Ltd.: Shaft bearings. 16,316.
Surtees, R.: Gears for reducing or increasing speed and reversing motion of driven shaft. 16,221.
Thompson, W. B.: Igniters for internal-combustion engines. 15,464.
Thorne, G.: Cooling piston-rods. 15,498.
Triumph Cycle Co.: Control mechanism for change-speed gears. 15,649.
Theriot, J. C.: Adjustable journal-boxes. 16,537.
Thierry & Co., G.: Sparking-plugs. 16,521.
Tanner, R. L.: Oil pumps for fluid-pressure engines. 15,898.
Thompson, T.: Internal-combustion engines. 15,880.
Vandervell & Co., C. A.: Dynamo-electric machines. 15,742.
Waterman Motor Co.: Internal-combustion engines. 15,476.
Watts, A. J.: Carburettors. 15,646.

White, S.: Generators of steam mixed with products of combustion. 15,590.
Wood, F.: Positive clutches. 15,710.
Wynn, H. F.: Liquid-level gauges. 15,672.
Watson, E. A.: Ignition magnetos. 15,837.
Webb, G.: Water-tight joints. 15,891.
Wolseley Motors Ltd.: Reversing multi-cylinder engines. 15,972.
Wade, H.: Braking explosion motors. 16,573.
Wale, A. E.: Conveyer driving, &c., belts. 16,553.

## COMPLETE SPECIFICATIONS ACCEPTED.

**1914.**

23,878—Bouteille: Carburettors.

**1915.**

11,646—Mills: Steam superheaters.
14,111—Zoelly: Power-transmission gearing.
15,306—Roots: Bearings of internal-combustion engines
15,524—Escoffier: Carburettors.
15,901—Sams: Feedwater-heaters.
15,926—Muntz: Taps or cocks.
16,012—Perrett: Fuel-jets for internal-combustion engines.
16,017—Canion: Triple valves for air-brake systems.
16,077—Carter: Steam glands of turbines.
16,598—James: Valves of internal-combustion engines.
16,919—Hick, Hargreaves, & Co., & Gunn: Pumps.
17,095—Michaud, Muller, & Heibel: Roller bearings.
17,203—Deighton: Steam-generators.
17,268—Mellersh-Jackson: Working internal-combustion engines.
17,746—Forbes: Fastening for driving-belts.
17,842—Kirke: Generation of steam.
17,991—Fletcher: Settings and external flues of steam boilers.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

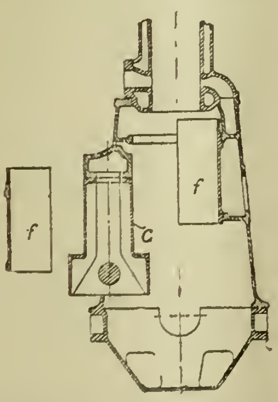
**1916.**

200—Higginson, J., and Arundel, H.: Internal-combustion engines. **101,984.**
771—Dallison, G. J.: Variable-speed and clutch mechanism. **101,896.**
1,217—Barclay, Curle, & Co., and Bell, J: Discharge valves. **101,992.**
1,520—Maschinenfabrik Oerlikon: Constructing turbine stators **100,055.**
2,311—Craig, A.: Crank chambers. **101,997.**
2,383—Wood, G. H.: Split steel lubricating and other rings. **101,911.**
2,502—Paxton, J. L.: Piston-rod packing. **102,000.**
2,982—Riper, L. C. van: Internal-combustion engines. **102,004.**
3,439—Knight, J. F., and Doudney, R. P.: Two-stroke internal-combustion engines. **102,006.**
3,609—Speese, J.: Rotary engines. **102,008.**
3,631—Sanderson, G. W.: Wave motors. **101,916.**
3,814—Kuhn, W. O.: Transmission gearing. **102,096.**
3,974—Thomson, J. D., and Thomson, G.: Friction gear. **101,918.**
4,526—Rasch, L.: Closing slits of packing-rings. **102,011.**
4,649—Ljusne-Woxna Aktiebolag: Internal-combustion engines. **100,305.**
6,499—Le Tall, F. W.: Marine turbines. **101,930.**
6,947—Potterton, T.: Gas-heated boiler. **102,109.**
7,048—Guttner, M.: Stuffing-boxes. **102,019.**
9,293—Albion Motor Car Co., and Murray, T. B.: Governor arrangement. **102,121.**
9,278—Fitzpatrick, H. D.: Suction pumps. **101,944.**
9,767—White, W. A.: Liquid-fuel furnaces. **101,947.**
9,854—Machin, W. A., Mills, E., and Downes, A.: Elastic-fluid engines. **102,027.**
10,164—Shenton, R.: Steam boilers or generators. **102,029.**
10,297—Lamkin, A. E.: Sparking-plugs. **102,128.**
10,569—Smith, J. W.: Cooling parts of internal-combustion engines. **101,952**
10,831—Bugatti, E.: Engines arranged in groups. **101,534.**

## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

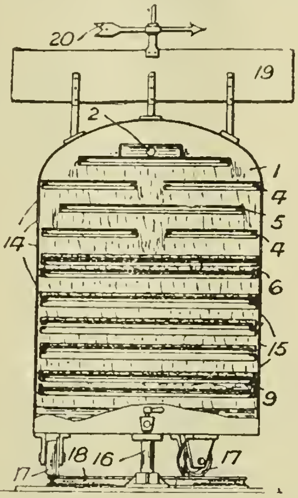
101,368.—W. D. McLaren and G. M. Welsh, 124, St. Vincent Street, Glasgow.—In order to enable the stepped pistons *c* of




two-stroke cycle engines to be readily removed through the crank chamber, the air-pump barrel *f* is removable entire with the piston; or, by dividing it longitudinally, only one-half is removable. Fig. 4 shows the latter construction applied to a two-cylinder engine with cross connections

### SOFTENING WATER.

101,314.—L. Linden, "Drumgowan," Claremont Road, Claygate, Surrey.—March 28th 1916.—In apparatus for softening water, the water is caused to flow in thin sheets or films and is repeatedly broken up into minute streams and is subjected successively to the action of carbonic-acid gas and to filtration to remove the carbonate formed. Water is supplied by an inlet 2 to a tower 1 and runs over and falls through a series of preferably perforated plates 4, 5, among which carbonic-acid gas, or air containing it, circulates a series of filters 6, 9 separate the carbonates formed. The plates in the lower compartment are covered with solid reagents, such as aluminium in fragments or in spongy form, and lime or, when sodium chloride is to be eliminated, spongy iron. The plates may be made of earthen-

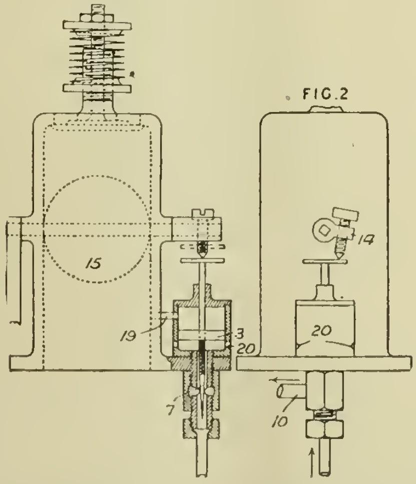



ware or ceramic materials in the paste of which the solid reagents are embedded before burning. Electric currents may be passed through the plates 5, which may be of copper. The carbon dioxide may be supplied by pipes to the separate compartments or may be supplied by the combustion of coke or charçoal in a furnace beneath the tower, or may be derived from the atmosphere, in which case opposite apertures 14, 15 in the casing are set in the direction of the wind. For this purpose, the tower is mounted on a pivot 16 and on wheels 17 running on a circular track 18, a vane 20 indicating the direction of the wind. A large vane 19 may be provided whereby the wind automatically adjusts the tower.

### INTERNAL-COMBUSTION ENGINES.

101,357.—J. C. Hansen-Ellehammer, 119, Istedgade, Copenhagen.—The main air supply flows downwards past a throttle valve 15, and the fuel is controlled by the varying vacuum on the engine side of this valve acting through a passage 19 upon a piston or diaphragm 3 attached to the fuel valve 7, and also by a lever 14 on the stem of the air valve which tends to limit the lift of

FIG 1

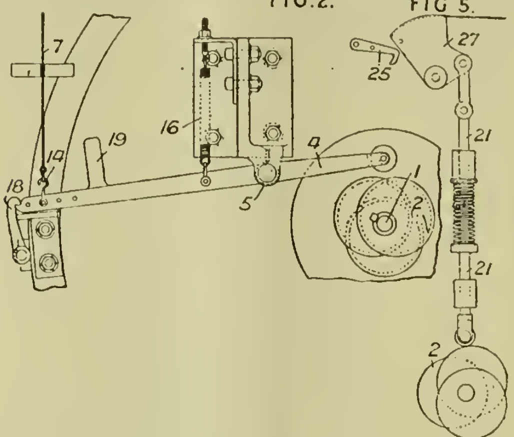



the fuel valve as the air valve closes. The fuel is supplied under slight pressure, and air which enters the space below the piston 3 through holes 20 may be drawn into the induction pipe with the fuel through the pipe 10. The fuel valve is connected to the piston 3 by means of a spring. The piston 3 may be actuated by the pressure of the engine exhaust

## STEAM-ENGINE AND LIKE INDICATORS

101,374.—A. RYDER, "The Laurels," Hartford, Northwich, Cheshire.—In multiple-cylinder engines, indicators fixed to each cylinder are driven by cam discs fixed on the crankshaft and angularly adjusted to be in phase with the corresponding crank, catches being provided to hold the tappets normally out of contact with their cams. Levers 4, Fig. 2, pivoted at 5, bear respectively on discs 2 upon the crankshaft 1 and are connected to the corresponding indicators by cords 7, attached to the levers 4 by hooks 14 or by quadrants. The levers are urged against the discs by springs 16, but may be held off by catches 18, for

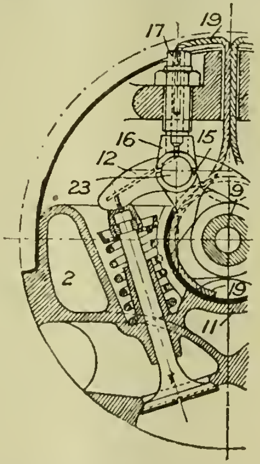
FIG. 2. FIG 5.




which purpose a handle 19 upon the lever is pressed down until the catch engages. The cord 7 passes over a quadrant on the indicator spindle, and, in the case of cylinders having pistons moving in phase, the indicator on the second cylinder may be driven from that on the first by a cord passing over quadrants on the spindles, provision being made for alterations of scale by suitable selection of the radii of the quadrants. In a modification, Fig. 5, plungers 21 bear on the discs 2 and serve to rock quadrants 27 which may be held back by catches 25. In another form, the cords are passed over pulleys and connected directly to the plungers.

## FLUID-PRESSURE ENGINES.

101,382.—E. WERY, 52, Meridale Road, Wolverhampton.—To facilitate inspection of the interior of the cylinder and the dismounting of the valves without disconnecting the inlet and exhaust pipes, etc., the valves and valve gear are mounted in an adjustable and removable head. Fig. 3 shows the invention applied to an internal-combustion engine. Housed in an angularly adjustable cylindrical head 2 are inlet and exhaust valves which are actuated by rocking levers 12 engaged by cams on a central shaft 9, the rocking levers being each supported on a spindle 23 carried in bearings 15 16. The valve gear is lubricated by oil supplied to a central tube 11, into which dip wicks 19 leading to spindles 17 supporting the halves 16 of the




bearings for the pins 23. The head, which is secured in position by a friction grip controlled by a hand wheel, turns about the cam shaft 9 when the grip is released by a hand lever (not shown). Additional securing means, such as clamps, may be used. According to a modified construction, the head is turned by a worm and worm wheel. Chain, bevel, or spur gearing may also be used. Water from the cylinder jackets is circulated around the head. According to a further modification, the head has a flat seat, the valve levers being housed in casings which may be turned about the axes of the cam shafts to facilitate access to the valves. Modifications are described in which the cylinder is extended around the head to form a seating therefor, and in which separate heads are used to house the inlet and exhaust valves.

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THE

# Industrial Engineer.

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## The Industrial Engineer.

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CONTENTS.



# EDITORIAL.

## NATIONAL SERVICE.

GENERALLY speaking, it is not considered the province of technical journals to enter into or take sides in political matters, such subjects being left strictly to the daily and weekly partisan press. This is a view rightly held, we think, in normal times, as technical journals can perform much more useful work for the community in whose interests they are issued by dealing with purely technical matters, and even here there is ample room for much difference of opinion to be expressed, and expressed well, without the necessity of falling out over it. Again, there must necessarily be great divergence of opinion on industrial matters, particularly as between the employers on the one hand and employees on the other, and in matters of this kind we hold that technical journals have not only the right, but in virtue of their position should express freely and disinterestedly their views upon these subjects.

The sphere of influence of a technical journal has been much enlarged and modified as a result of the war, and it is now not only necessary, but desirable to deal with matters which concern the interests of the nation at large. In this respect, therefore, we heartily welcome the new Prime Minister's reference to the mobilising of the remaining civil portion of the population into an army of national service. It has been necessary from the first, in our opinion, and it is gratifying to know that we are in sight of efficiency at last. That we require it there can be no manner of doubt amongst intelligent observers. In this regard no persons know better than those engaged in engineering, and as this has been termed an engineers' war, and as engineers are, or should be, the first to admit efficiency in organisation, they will be the first to acknowledge the necessity for an enlargement of the scope of national service. We are getting thereby on to thorough business lines, and paving the way also for national service in accumulated wealth. It looks as though complete national service from every point of view will be a paramount necessity before this terrible war is ended. There can be no legitimate complaints on that score, for no amount of service rendered in a civilian capacity, whether in labour or money, can equal the service rendered by our brave and superb fighters on land and sea, who are daily facing the possibility of life-long disablement and death in the service of their country. For such service those at home can never pay enough. For this reason every shoulder should be put to the national wheel in the days that are to come. We shall all be happier for it, and it is due to those who are bearing the brunt for our sakes to leave no stone unturned to help them in securing a glorious and lasting victory. The proposed national service will secure this. There is no other way. It is only to be hoped that we shall not be too late in perfecting its organisation.

ELECTRICALLY-OPERATED EXCAVATORS.—Electrically-operated excavators are being used on a large drainage scheme in Idaho, U.S.A. Energy is obtained at a pressure of 44,000 volts from an overhead line; the average power consumed is 0·88 kilowatt hour per cubic yard of material excavated, varying with the material excavated, being as low as 0·39 kilowatt hour in light sandy loam, including all line and transformer losses.

## NATIONAL ELECTRIC POWER SUPPLY.

*(Continued from page 89.)*

### LANCASHIRE AND CHESHIRE SCHEME.

In connection with the same subject, we have received from Mr. J. A. Robertson, hon. secretary of the Committee for the interconnection of Lancashire and Cheshire Electricity Supply Systems, a copy of the Interim Report of the Committee, which forms very intresting ing stations, existing E.H.T. mains, and proposed new mains in the areas included in the scheme. It is interesting to note that the economy anticipated in coal consumption alone, as the result of interconnection of the generating stations, is estimated at £82,000 per annum at 17s. 6d. per ton.

The report, after drawing attention to the necessity for conserving the nation's resources and increasing its producing capacity during and after the war, which


Lancashire and Cheshire Scheme: Map of Area, including Groups A, B, C, and D.

reading. It is dated September, 1916, and after discussing the question of economy and the needs of the existing situation generally, details the proceedings of the Committee since its inception on May 9th, 1916. Various recommendations are made with a view to coordinating the electrical supplies in the districts concerned, and in a number of appendices a mass of data and statistics is set forth. We reproduce herewith a map which accompanies the report, showing the generat-

has made the subject of electricity supply one of vital and immediate importance, states that it does not profess to deal with questions of general policy, nor does it advocate any comprehensive scheme of centralisation. Its object is rather to indicate the means which can be adopted at once for utilising existing facilities to the fullest extent, so as to meet the present abnormal conditions, and to prepare for the situation which will arise after the war.

Certain conditions arising out of the war have an important bearing on the question:—

(*a*) The restrictions imposed by the Government on capital expenditure, and the consequent postponement or abandonment of extensions to existing supply undertakings.

(*b*) The increased price of fuel and other materials, and the scarcity and high price of labour.

(*c*) The increased adoption of electricity for power purposes, and the necessity for cheapening its production to meet industrial requirements after the war.

To cope with these conditions, the Committee has drawn up a scheme for the interconnection of existing electrical undertakings in certain districts in Lancashire and Cheshire, as a result of which it is believed that the following immediate benefits will be derived:—

(*a*) The supply from existing stations could be greatly increased, as the generating stations in each district would to a considerable extent act as a reserve or stand-by to each other, thus reducing the amount of reserve plant which has to be kept in readiness in each station in case of emergency. It is estimated that if the generating systems in the areas under review were interconnected the aggregate maximum demand on the whole system could, under normal working conditions, be increased by 30 per cent.

(*b*) The risk of interruption to supply would be materially diminished in the event of an accident occurring to the plant in one station, as the supply could be maintained from one or more stations in the same district.

(*c*) By making the fullest use of the efficient plant on each system, and only running the less efficient plant at times of heavy demand, a considerable saving could be effected in fuel, and to a lesser degree in wages, repairs, and other items of expenditure.

(*d*) A number of the generating stations in each district could be shut down at week-ends, and at times of light load, thus improving the general efficiency of the system, and permitting necssary repairs and overhauling of plant to be carried out with convenience and economy.

(*e*) The interconnection of electrical undertakings by reducing the amount of stand-by plant would greatly conduce to economy of capital expenditure in future.

The Committee was formed on May 9th, some weeks before the Board of Trade circular on interconnection was issued, held its first meeting on May 16th, 1916, and decided to consider the problem in the first place from its engineering aspect. For the purpose of the scheme the undertakings in the area were divided into six groups, namely:—

GROUP A.

Altrincham Electric Supply Co.; Eccles Corporation; Lancashire and Yorkshire Railway; Middleton, Manchester, and Salford Corporations; Sale and Stretford U.D.C.'s; Stockport Corporation; Trafford Power and Light Supply Ltd.

GROUP B.

Bolton and Bury Corporations; Heywood U.D.C.; Lancashire Electric Power Co. (Radcliffe); Leigh Corporation; Radcliffe U.D.C.; Rochdale Corporation; South Lancashire Tramways Co. (Atherton); Wigan Corporation.

GROUP C.

Ashton-under-Lyne Corporation; Glossop Supply Co.; Oldham Corporation; Stalybridge, Hyde, etc. (joint board).

GROUP D.

Accrington, Blackburn, Burnley, Colne, Darwen, and Nelson Corporations; Preston Corporation Tramways; Preston Electric Light Co.; Rawtenstall Corporation.

GROUP E.

Birkdale and District Electric Supply Co.; Birkenhead and Bootle Corporations; Hoylake and West Kirby U.D.C.; L. and Y. Railway (Formby); Liverpool Corporation; Liverpool and District Co.; Liverpool Overhead Railway Co.; Mersey Railway Co.; Mersey Power Co. (Runcorn); Ormskirk (Company); Prescot and District Lighting Co.; St. Helens, Southport, Wallasey, and Warrington Corporations.

GROUP F.

Alderley and Wilmslow Electric Supply Co. Ltd.; Crewe and Chester Corporations; Macclesfield Electricity Co. Ltd.; Northwich Electric Supply Co.

A technical census of these undertakings has been made, and the results are tabulated in an appendix. The map given shows the position of the generating stations, and the extent to which extra-high-pressure mains have already been laid in the area of supply under consideration.

At an early stage in the proceedings the Committee came to the conclusion that no useful purpose would be served by the inclusion of the five undertakings of Group F, and consequently these have been dropped out of the scheme.

Extra-high-pressure mains have been laid to a much greater extent in the districts included in Groups A, B, and C than in the others, and a scheme for interconnecting the undertakings within these groups could be carried out at a comparatively small cost and with little delay. The majority of the undertakings included in Group D can also be conveniently linked up with each other, but the interconnecting of this group with Groups A, B, and C is not provided for at present. The district within which the undertakings included in Group E are situated is a very wide one, and to interconnect all these undertakings at the present time would entail a capital expenditure out of proportion to the realisable savings. This does not, however, rule out the possibility of adjacent undertakings in this district linking up by mutual agreement.

The Committee, after careful consideration, therefore, has decided for the present to confine its proposals to the four Groups, A, B, C, and D, comprising 32 undertakings. In Group A, the cost of linking up Sale and Altrincham with the other undertakings in the group could not be justified at present, and this also applies to the two Preston undertakings in Group D. There remain, therefore, 28 undertakings, which include the Lancashire and Yorkshire Railway Co.'s 25-cycle system and the undertaking of the borough of Eccles. The Committee makes no proposals for dealing with these two undertakings in this report, the first named on the ground of expenditure involved, and the last named on account of the necessary information being withheld. Of the remaining 26 undertakings, the majority are operating on the three-phase alternating-current supply system with 6,600 volts as the pressure of generation and transmission, and 50 periods as the frequency of the system.

Six appendices give information regarding the undertakings included in Groups A, B, C, and D, under the following heads:—

Capital expenditure and plant capacity.

Units generated and coal consumption.

The estimated capital expenditure involved.

New mains and transformers to be provided for interconnecting purposes.

Principal features of the returns from the undertakings.

Lancashire and Cheshire Electricity Supply Systems —tabulation of technical data.

The estimates in Appendix 3 are based on the abnormal prices now ruling for materials, and, with one or two exceptions, allow a section of not less than 0·15 square inch of copper on all new mains, and sufficient capacity of transforming plant to enable any undertaking to receive not less than 3,000 kw. from the adjacent undertakings with which it is connected.

Interconnected stations would enter into arrangements to give, receive, or exchange electrical supplies for one or more of the following objects:—

(*a*) For the purposes of economy only—*i.e.*, to avoid the inefficient running of plant or to facilitate the shutting-down of stations during the week-ends, at night, and at all other times of light loads.

(*b*) For stand-by purposes, *i.e.*, for emergencies.

(*c*) For bulk supplies, *i.e.*, in case of a shortage of plant or for economical reasons.

The Committee, after careful consideration, has come to the conclusion that if the undertakings in Groups A, B, C, and D are interconnected, the average coal consumption per unit generated, viz., 3·24 lbs., can be reduced by not less than ·5 lb. of coal per unit. With coal at 17s. 6d. per ton, this reduction represents an annual saving on the present output of the undertakings of about £82,000.

Having arrived at these preliminary conclusions, the Committee considered it desirable to ascertain more definitely the views of the Government departments concerned on this question, and, after correspondence, a deputation consisting of Mr. Pearce, Mr. Purrett, Mr. Welbourn, Mr. Robertson, Mr. Watson, and Mr. Wheelwright, on July 13th, was received by representatives of the Board of Trade, the Local Government Board, and the Treasury.

The deputation, in the first place, fully explained the steps that had been taken, and advanced the view that, as the whole scheme was part of a national effort to effect economies, and as the return on the outlay involved was so substantial, the Government might favourably consider the question of providing the necessary capital to effect the interconnection proposals on such terms as would prove a strong inducement to the several parties interested to proceed with the scheme. A representative from the Treasury said he was authorised to say that the Treasury would favourably consider the expenditure of moneys required for the scheme, provided that the Local Government Board and the Board of Trade were satisfied with the proposals which might hereafter be submitted to them.

With regard to the coal saving, a representative of the Board of Trade pointed out that, viewed from the national standpoint, the annual saving to the country would be substantially greater than the sum of £82,000 estimated by the Committee, as the present-day export value of coal was 45s. to 50s. per ton.

Considerable discussion ensued with regard to the procedure which would be necessary to give effect to the Committee's proposals.

*(To be continued.)*

## HEAVY-OIL ENGINES.*

By S. B. Daugherty.

### What Kind of Oil is Suitable.

In a consideration of the oil engine, the questions at once arise: What kind of oil is suitable? Are supplies of fuel available in sufficient quantities in various parts of the country? Will the probable production of oil in years to come be equal to the demand? To answer the first question requires a word of explanation as to the types of oil engines. Broadly, there are two—the low-compression engine, wherein ignition is effected by the injection of the oil spray against a heated surface, or even by an electric igniter, as in gas engines; and the high-compression or Diesel type, with ignition from the heat of compression of the air charge. The low-compression engines are the simpler and cheaper, but, on the other hand, suitable fuels for use in them are fewer and higher-priced, and the thermal efficiency is less. These limitations tend to restrict the use of low-compression engines to smaller installations. Suitable oils are kerosene, the lighter distillates, and light crude oils.

The high-compression or Diesel-type engines can in general utilise any liquid fuel. It is to be remembered that there is no strict line of demarcation between the types, but that they tend to merge one into the other. The grades of suitable oils vary inversely as the grade of the engine—the cheaper and simpler the engine, the higher the grade of oil required; the more elaborate and specialised the engine, the lower the grade of oil which may be successfully used.

The date of the beginning of the production of petroleum or mineral oil in the United States is recorded in Government publications as 1859, the production of that year being 2,000 barrels of 42 gallons each. The United States production marketed in 1914, the last year for which statistics are available, was 265,762,535 barrels.

There are six major oilfields of the United States: The Appalachian, the Lima Indiana, the Mid-Continent, the Illinois, the Gulf, and the California. The quality of the oil produced in the Appalachian field is the best. It is light, yielding a large percentage of gasoline and kerosene, and paraffin is obtained from the residuum; the Lima Indiana oil is also light, but contains sulphur; the Illinois oil contains less sulphur than Lima Indiana oil, but contains some asphalte as well as paraffin; oils of the Mid-Continent field contain paraffin and asphalte, and show considerable variation; those from the Gulf field contain considerable sulphur, while the California oils in general contain much asphalte and considerable sulphur. Some of the California oils are valueless to the refiner, and find their market as fuel oil or as road oil.

### Oil in Mexico.

In addition to the oil produced in the United States, there is an enormous potential production in Mexico. This oil is asphaltic, and contains often as much as 3½ per cent sulphur. It finds a ready market as fuel oil, and can be sold in the ports of New England at a price that allows of its being used as fuel under boilers in competition with coal. In Florida, Mexican crude is used extensively. A general survey of the statistics shows that the total production of oil in the United States is increasing. This increase is in the lower-grade oil, as the production of the Appalachian field is decreasing,

* Paper presented at a meeting of the Chicago section of the American Society of Mechanical Engineers, March 17th, 1916.

even though the price has recently been maintained at a fairly high level.

New fields are being discovered, and the limits of old fields are being extended. It is probable that for many years the total production will increase. In fact, it is the opinion of experts that the petroleum resources of the

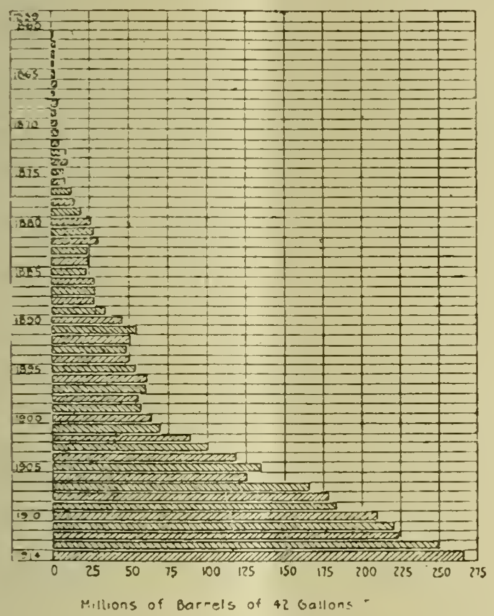



Fig. 1.—Annual Output of Petroleum in the United States.

world are relatively undeveloped. Some fields are enormously productive, as, for instance, the Cushing pool, which a year ago was producing at the rate of about 30,000 barrels per day; the production of this field has decreased so that now it is about 12,000 barrels daily.

Consumption of petroleum products is constantly on the increase. This applies particularly to gasoline. It is estimated that the automobiles of this country are consuming over 1,000,000,000 gallons annually. In addition to this amount, the yearly consumption of gasoline for other purposes is about 500,000,000 gallons. It is in this enormous demand for gasoline that there is an assurance of a reasonable supply of oil suitable for use in engines. Part of this supply is the residue from refining operations, and a great portion is in the lower grades of crude oil discovered in the search for new supplies. Fig. 1 shows the

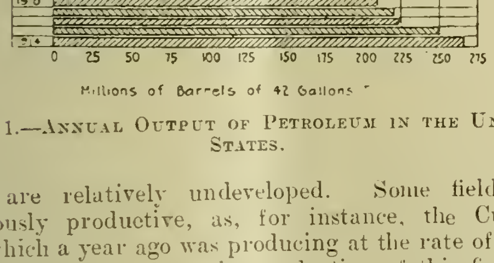



Fig. 2.—World's Production of Petroleum in 1914.

annual production of petroleum in the United States from 1859 to 1914. Fig. 2 shows the total production of the world for 1914, and the percentages produced in the different countries.

A first impression would be that any decided increase in the number of oil engines in use would create such a demand for fuel oil that prices would advance to a figure which would make the oil engine unprofitable. But this does not take into consideration the fact that in many cases the oil engine supplants an oil-fired boiler, and that but one-fifth to one-tenth of the oil burned under the boiler is required for the oil engine, the remainder being available for other purposes. It must also be remembered that the price of fuel oils is largely determined by the price of other fuels. Heat units in oil must not be much higher priced than heat units in other fuels, or there is no market for the oil. For many years the price of low-grade oils will be determined by the demand for other purposes than use in oil engines.

## Oil Engines, Diesel and Semi-Diesel.

This paper will consider Diesel-type engines particularly. The Diesel engine is the most economical prime mover yet designed. It is now 22 years since the engine was patented in Germany. The engine was developed by the Augsburg-Nürnberg Company. The first commercial engine was put in service in 1897, and according to the Augsburg-Nürnberg Company, was still in service and running satisfactorily in 1911.

The Diesel engine is unique, in that it was designed to fit a theory. Some of the paragraphs in Diesel's patent show clearly that his calculations were not entirely correct; for instance, his statement that there is "no increase in

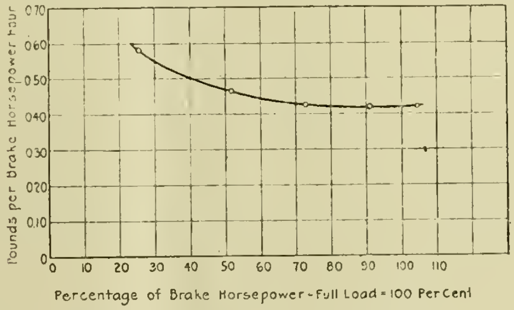



Fig. 3.—Fuel Consumption, 4-Cycle "Snow" Oil Engine, from Actual Brake Tests.

the temperature produced on the introduction of the fuel, or at most only a very slight one, and the highest or extreme temperature is produced by the compression of the air. It is, therefore, under control, and will be kept within moderate limits, and, moreover, in view of the cooling of the products of combustion by the subsequent expansion, no artificial cooling is required for the cylinder, the mean temperature of the gases being such that the parts of the engine can be kept tight and lubricated"; also that "the exhaust may be cooled by expansion below the temperature of the atmosphere and utilised for refrigerating purposes." Experiment has proven these statements incorrect, but in its essential features his theory was sound. The first claim in his patent covers the engine so completely that, so far as I am aware, no infringement was ever attempted. This is the claim: "The herein-described process of converting the heat energy of fuel into work, consisting of first compressing air, or a mixture of air and neutral gas or vapour, to a degree producing a temperature above the igniting point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air, expanding against a resistance sufficiently to prevent an essential increase of temperature and pressure, then discontinuing the supply of fuel and further expanding without transfer of heat."

The first Diesel engine was a vertical machine, and this

design was followed in subsequent engines until it became so standardised in Europe that the opinion prevails to a great extent that there must be some vital reason for the adoption of the vertical type. The first commercial engine was a twin-cylinder vertical engine of 60 B.H.P. Both horizontal and vertical Diesel engines are now being built in the United States, and the expiration of Diesel's patent in July, 1912, was the occasion of many builders entering the field.

In addition to Diesel engines, the De La Vergne type FH engine should be mentioned. It is classed as semi-Diesel, but its equipment includes all of the essentials of a Disesel engine, and the compression needs only to be raised from about 350 lbs. to 500 lbs. in order to bring it into the Diesel class. The economy of this engine is practically the same as that of the true Diesel type.

### Economy of the Diesel Engine.

As stated, the main feature of the Diesel engine is its economy. The measure of efficiency of a prime mover is the percentage of potential power actually obtained for useful work. In the transformation of heat energy into useful power various losses occur. If steam be the medium, there will be a loss of heat in the boiler, due to radiation, to the escape of heat into the stack with the gases formed by combustion of the fuel, and to imperfect combustion of the fuel. Heat in the steam is lost by radiation, and a very considerable amount is rejected in the exhaust. Friction accounts for a further loss, and so, with steam as a prime mover, the percentage of actual heat in the fuel that is transformed into work ranges from 6 to 16 per cent. For intermittent operation, where a considerable portion of the fuel burned is for stand-by service, the percentage may be even lower. In the internal-combustion engine the heat losses are due to radiation, to heat carried off in the jacket water and in the exhaust, and to friction. The principal saving is in the reduction of the amount of heat lost in the exhaust.

The effective thermal efficiencies of various prime movers are about as follows:—

| | Per cent. |
|---|---|
| Non-condensing steam engine ... | 8·4 to 6·6 |
| Condensing steam engine and turbine using superheated steam ... | 15 ,, 10 |
| Suction gas engine ... ... ... | 23 ,, 18 |
| Four-cycle Diesel engine ... ... | 34 ,, 32 |

The significance of this Diesel-engine economy can best be appreciated by a familiar comparison: Assume that a touring car can be run 12 miles on a gallon of gasoline, which costs 23 cents per gallon and weighs about 6 lbs. Assume that the engine has a thermal efficiency of 18 per cent, and that the effective heating value of the gasoline is 114,000 B.T.U. per gallon.

Fuel oil weighing about 7·5 lbs. per gallon would have an effective heating value of about 135,000 B.T.U. per gallon. On this basis of relative heat values and efficiencies a Diesel-type engine would drive a car 26 miles on a gallon of oil, as compared with 12 miles with gasoline. But 7·66 gallons of oil can be purchased for the price of one gallon of gasoline, so that the distance covered for 23 cents worth of fuel would be 200 miles with oil and 12 miles with gasoline, or 16·6 times.

Fig. 3 shows the fuel-consumption curve of a single-cylinder four-cycle engine. At loads from 80 per cent to full load the consumption is practically constant, and at the rate of 0·42 lb. per brake horse-power hour. At this rate one gallon of oil will furnish about 18 brake horse-power hour, and the cost for fuel per brake horse-power hour with oil at 3 cents per gallon is 1⅔ miles. To supply 100 H.P. for 10 hours would require 55½ gallons of oil, costing 1 dollar 67 cents.

The opponents of internal-combustion engines, both gas and oil, always state that these engines are economical only when operating near maximum load, and that the economy falls off rapidly as the loads decrease. Observe on this curve that the load is approximately 42 per cent where the consumption curve crosses the 0·5 lb. line, and that the consumption at half load is 0·47 lb. The fuel consumption for a 10-hour day, running a 100-H.P. engine at half load, would be about 31½ gallons, costing, at 3 cents per gallon, 95 cents. It is evident that the fuel expense for keeping an engine running on friction load is very slight. By actual test on a 65-H.P. engine, full speed with load was maintained on 1·1 gallons per hour.

*(To be continued.)*

## FRICTION CLUTCHES.*

By William G. Gass, M.I.M.E.

It is a little difficult to know where to commerce the treatment of a subject like a friction clutch, which is not a machine in itself, but only a part of machinery, and of which there is so great a variety, so many makers, and such extended use. The author does not therefore propose to deal with any one type, but to review the general types into which they may be classified, to refer to their common points and detail, and as far as possible their weaknesses and faults; not with the idea of extolling one type against another, but by bringing their faults to view to help towards their removal, for it is only by consideration of weak points that we can strengthen them. It may be taken as an axiom that, though one type of clutch may have advantages over another, there is not any perfect clutch, some types answering better than others for different classes of work; this is a great point to bear in mind when arranging clutch drives. We may commence by defining a clutch as a mechanical device by which rotary motion is transmitted from a first-motion shaft to another or second-motion shaft, which may be either in the same straight line or parallel with it. Clutches are divided into a number of distinct types: (1) Claw couplings, (2) friction cones, (3) internal segment and band clutches, (4) external segment and band clutches, (5) plate clutches, (6) brush clutches, (7) magnetic clutches, (8) automatic clutches.

### Claw Couplings.

Claw couplings cannot be generally classified as friction clutches, but they can be and are combined with a friction slipping device by which some of the shock is absorbed when thrown into gear with the prime mover when rotating. Without any friction device they are very useful on machines where the load is not very great, as they have all the advantages of giving a drive with no chance of slip. Where used for transmitting heavy loads or at high speeds they should only be put in gear when the machine or shafting is stopped. They are also very difficult to release when transmitting heavy loads.

### Friction Cones.

These are the simplest form of friction clutch, and for some purposes the best, because simple in construction; if properly made they drive very well; they have the serious

* Paper read before the Manchester Association of Engineers, October 28th, 1916.

lefect, for general use, of requiring to be held up with a constant pressure, which absorbs power and causes wear on the setting-up gear and the bearings taking the thrust of the setting-up gear. A portion of the constant thrust can be eliminated by making the angle of the internal portion sufficiently small, but this makes the cone liable to stick, and it is not infrequent, when large cones are so made, to have to hammer the outside of the cone to make the two portions come apart.

If, on the other hand, the cone angle is too large, the pressure required to keep the two parts in gear is so great that it is very difficult to transmit the power. Generally, these large cones are used for driving machinery in bleach-works and similar places, and are useful where there is a good deal of wet about. They are usually made of cast iron, the inner part sliding on the shaft on float keys, the outer part running loose on the shaft. They have been tried as double cones with internal and external bearing surfaces, but there is nothing to justify such an arrangement. If covered with some frictional substance such as leather, or any of the numerous frictional materials made for the purpose, the driving power is increased.

In motor cars the cone has proved a most valuable type, as the usual conditions are reversed, and it is as a constant driver that its value comes in. The arrangement in motor cars is such that there is no end thrust except when it is not transmitting power, and is, therefore, working under the best conditions.

### Internal Segment or Band Clutches.

These are divided into two distinct types—those in which the internal segment is in two or more sections, which are forced apart by means of screws usually; and those in which the internal segment is cast all in one piece, so arranged that the driving portion is expanded against the spring of the metal. This type is made in two forms; in one case the segment is sprung apart at two points, and the other in one place only. Similar forms are made with hinged portions. In the loose segment type the segments are carried on the arms of a turned internal piece, usually keyed on to the shaft as driver, but in other cases sliding in grooves made to receive them in the driven portion.

### External Segment or Band Clutches.

The external segment or band clutch is made in quite as many forms as the internal-band type, but is more generally used for the smaller powers. The segments are in two, three, or four pieces, forced on to a central drum, and carried in much the same way as the previous type. A single band, similar to a brake drum strap gripping on a central drum and set up by a wedge, is one form; another has two bands and is set up from opposite sides. Another takes the form of a spring coil which tightens up by tension and friction, and is, in fact, an external cone clutch with a flexible rim. It is not usual to consider a fast and loose pulley drive as a clutch, but it comes under this head, the belt being the external friction band.

### Plate Clutches.

A plate clutch is distinct from any of the other forms, as the gripping surface is between two or more flat plates pressed together, one plate being attached to the driver and the other to the driven alternately. These are forced together by levers through a toggle joint. Another form of this type has the plates of stamped steel formed into a kind of double cone, which is supposed to give it extra gripping powers.

### Brush Clutches.

These utilise the resistance of a great number of projecting wires which, when the two portions are pushed together, interlock, and give the necessary power of driving.

### Magnetic Clutch.

Magnetic clutches have generally two flat faces, though conical surfaces have been used, which are pulled together by the power developed in an electro-magnet formed in one-half the clutch.

### Automatic Clutch.

Automatic clutches depend on centrifugal action to keep the surfaces in contact, and are used in connection with electric motors, being designed usually to come into operation at certain desired speeds.

The foregoing brief summary of the different types makes it evident that their number is very great, and that it would take more than the space available to describe them in anything approaching detail. They, however, all possess points and faults in common, and it is these which it is proposed to consider as well as their other features.

### Driving Surfaces.

These are for the most part metal on metal, usually cast iron on cast iron. In cones, and in internal segment clutches, in the old days they used to be covered with copper plates riveted on by copper rivets. Many of the old-time millwrights, particularly in bleach and similar works, would not have anything else, but there are not many made so at the present time. Copper covering did not materially increase the driving power, but it was generally believed to do so. If the clutch were heavily loaded there was a tendency for the copper to creep and shear the rivets. Examination of the surface of the copper after long work showed the surface was embedded with fine particles of iron from the outer part of the cone or clutch, and it became hard and glazed, the pieces of embedded iron being hard and exceedingly sharp.

There are several kinds of friction material now made which are recommended for clutches. These, no doubt, are of advantage for brakes, but there are difficulties in the way of using them for clutches. In most cases rivets have to be depended on, and these are apt to give way. The material is liable to glaze, particularly where the clutch goes in and out many times. Wooden blocks as driving surfaces act very well if the load is not excessive, but if overtaxed they char on the surface and give way. Where steel is used it should not be used on cast iron unless its surface is chilled very hard, or, if on steel, on a case-hardened surface. Some of the smaller kinds of clutches use two hardened surfaces, but this must reduce the driving power.

In plate clutches cast iron on cast iron is, in the author's opinion, best, mild steel on cast iron being a failure. One clutch uses a double cone arrangement in which the pressure is on the inside and the outside, and steel plates are used throughout. A great deal is claimed for this, and it is satisfactory as long as it is attended to and not overloaded. In motor cars leather-faced cone clutches are in the majority, and the results justify their popularity; they have to work so much as a slipping clutch that metal-to-metal surfaces have not proved satisfactory unless lubricated. In these the coefficient of friction is, of course, higher than metal to metal. In magnetic clutches fibre on iron is usual, and they are said to give good results.

The trouble of driving surfaces is that they wear away, and this wearing is greater or less as the clutch slips or not. It is obvious that faces of metal cannot slip on one another

under pressure without wearing away, and the examination of surfaces which have been in use shows the way in which the loss occurs. The surfaces generally being dry a small portion of metal gets embedded into whichever of the surfaces is the softer, and acts as a kind of plough into the other. It is not necessarily the softer of the two which gives way, but often the harder. This does not sound quite reasonable, but it is a fact. If you take a lead plate and cover it with particles of emery it will cut away the hardest steel. It is not, of course, the lead plate that cuts, but the emery. The same thing occurs with the clutch; particles of hard material, got embedded in the softer, and act as the cutting material, but only when the clutch is slipping, so that the wear may be slow or fast depending on whether the driving faces slip much on each other. This explains why clutches put in as slipping clutches are not often very successful.

*(To be continued.)*

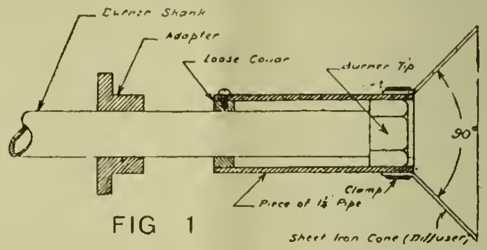
## SOME EXPERIMENTS IN NATURAL-DRAUGHT OIL BURNING.

Lieut. L. R. Ford, U.S.N., in an article in the August issue of the Journal of the American Society of Naval Engineers, gives an interesting description of experience in oil burning on the U.S.S. "Fulton." At the time the ship was commissioned, the steam necessary to operate the auxiliaries was supplied by a Roberts water-tube boiler equipped with one large burner, which used either steam or air as an atomising agent. The air for combustion was supplied by natural draught through two small ventilators and through the door between the engine-room and fire-room. After a disastrous furnace explosion, due to the burner flame being extinguished and the furnace becoming filled with explosive gas, which ignited, the boiler was fitted with two of the Bureau's standard type air registers and burners. These burners atomise the oil mechanically and are designed for use with forced draught. In addition, a second boiler of the Almy water-tube type was installed, which made the room quite crowded and curtailed the already limited air supply.

As soon as the ship was ready to leave the Navy Yard troubles began. When the burners were lighted under one boiler, it became evident that the combustion was very poor. Several schemes were resorted to. Small portable electric blowers were placed on the fire-room floor plates so as to discharge against the registers in the furnace front. This helped only slightly. A sheet-metal box built on the boiler front so as to completely enclose the registers and burners, and connected with two ¼-H.P. portable blowers, proved to be a failure. A small box was then built that would stand on the floor plates in front of the burners, with the two ¼-H.P. blowers connected so as to discharge into the box. This improved the combustion, but far from sufficiently. So much soot was deposited that it became necessary to establish a routine requiring that the tubes be blown with steam once every hour or 24 times each day.

The oil pressure habitually carried with the Bureau type of burner was 200 lbs. It was found that by reducing the oil pressure much better combustion was obtained, but the oil was then insufficient to maintain the steam pressure. Several types of experimental burners with either air or steam atomisation were tried, but without much success. Finally, the following system was adopted on the advice of Lieut. A. M. Penn, U.S.N., in charge of the fuel-oil testing plant at the Navy Yard, Philadelphia.

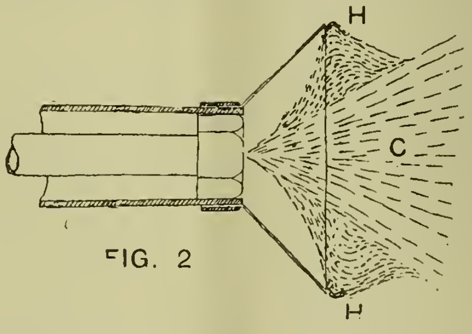
The Bureau standard type registers were removed from the furnace front of the Roberts boiler and a bar of ¾ in. by 3 in. flat iron was supported across the front of each opening in the furnace front on ⅝ in. studs, these studs projecting 10 in. from the furnace front and being provided with threads and nuts for adjusting the bar for distance. Each bar was drilled at its centre large enough to permit the insertion of a burner. The burner itself was modified as shown in Fig. 1. A funnel-shaped diffuser was made of sheet iron and attached to the end of a piece of 1¼ in pipe, 4 in. long, by means of a band




Some Experiments in Natural-draught Oil Burning.

clamp. This clamp method of securing the diffuser on the pipe was preferable to screws or rivets, as it permitted easy removal of the diffuser. The included angle of the diffuser was selected after several experiments as 90 deg., and the diameter at the large end was made 4⅝ in. The pipe was slipped over the tip in such a manner as to permit adjustment of the distance the burner tip projected into the diffuser.

When this burner was lighted a most interesting action was observed. With the diffuser drawn well back towards the rear, the flame would jump away from the burner, but when the diffuser was pushed forward it would pick up the flame, and a short cone of clean flame would result. When the diffuser was adjusted to the best operating position, a halo of white flame would appear around the edge, as shown in Fig. 2. The main




Some Experiments in Natural-draught Oil Burning.

body of the flame retained its cone shape, as shown at C, this cone of flame extending back to the burner tip; but part of this flame seemed to draw out to the diffuser and curl down from the edge, as shown at H. The combustion obtained with this arrangement was very good indeed.

Among the modifications introduced were the installation of vertical fins of thin sheet metal in the shape of a helix around the circumference of the conical openings in the furnace, to promote mixing of air and fuel by giving the entering air a rotary motion. Another improvement was the mounting on the head of the oil

line a large air chamber. This chamber kept the oil pressure steady, the effect of which was quickly noted at the burners. When the diffusers were adjusted to get the halo around the edges, it remained there without further adjustment. What surprised the ship engineers most was the low oil pressure required to maintain the steam pressure and the wide range of pressure through which the burners could be operated smokelessly. Under the old conditions it had been necessary to operate the burners under an oil pressure of 200 lbs. It was now found that the steam necessary to meet the normal demand of the ship could be evaporated with an oil pressure of 50 lbs. to 100 lbs., and the pressure had to be raised to 200 lbs. only when an extra demand for steam was made. In fact, it was found that the steam pressure could be quickly and closely regulated by varying the oil pressure, which could be done by varying the spring tension of the regulator valve on the oil pump. Steam control was thus reduced to the mere screwing of a nut up and down with a wrench, a novelty which strongly appealed to the fireman.

The helical vanes, in addition to giving the air a rotatory motion and thereby promoting mixture of air and oil, serve a useful purpose in intercepting the radiant heat from the flame. It is found that since they were installed the heat in front of the boiler is now greater than when the closed registers were in use.

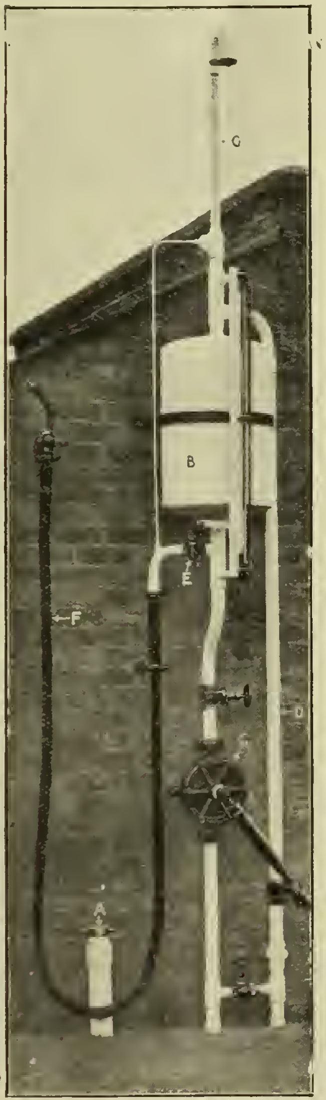
## A RUSSIAN CANAL.

The rivers of Russia, though they are the longest in Europe, have a most sluggish course and flow into the inland seas for the most part. They rise in the great Russian central plains, and for that reason present great opportunities for work in the direction of canals and canalisation. A scheme at present in hand was planned to cost £16,700,000. The idea is to make a great canal, divided into portions. The first was to consist of the regulation of the western Dwina from Riga to Vitebsk, and was to be 360 miles in length. The second portion was to be the canal proper from Vitebsk to Orsha on the Dnieper, 52 miles long. The third and southern portion would be the regulation of the Dnieper from Orsha to Kherson, 1,055 miles long. In all, the canal would, when complete, be 1,473 miles. It will be at once perceived what an immense gain to Russia the proposed canal will be when constructed. It will traverse her richest agricultural district, and greatly facilitate the export of her grain. The chief towns upon this waterway include several important centres. These export, among other items, grain, timber, flax, naphtha, petroleum, sugar, tobacco, fruit, and vegetables. What the country wants mostly is agricultural machinery and manures. Germany has hitherto supplied Russia with these; it remains for Britain to do it in future. The economical and strategical value of this canal is concentrated in one fact—it would, to a great extent, make Russia independent of the Dardanelles. Goods would pass in twelve days from the Black Sea to the Baltic. Some progress has been made with the canal. In the summer of 1913 a good deal was done between Ekaterinoslav and Gradizkok in the way of blowing up submerged reefs and obstructions to small rapids, and deepening river beds. A large sum of money was allowed for this portion of the work, and it was expected to take four years. The deepening of the river between Ekaterinoslav and Kiev has been commenced. From Kiev to Orsha the banks have been strengthened and the channel deepened. In the Vilna district a fresh canal has to be made from Orsha to the Dwina. On the Dnieper from Alexandrovsk to the sea the canal is ready for use. Had the whole canal been ready for use, how greatly it would have aided Russia just now. The above has been abridged from an article on the general subject of internal water communications of Russia in "Chambers's Journal."

## PETROL STORAGE.

[The Steel Barrel Co. Ltd., Uxbridge, Middlesex.]

To those who are unacquainted with the varied products of the Steel Barrel Co. Ltd., of Uxbridge, it will not appear strange that they should receive special mention in the columns of this journal, since they are of general application. This company has gained world-wide renown for the casks of barrel shape which they manufacture—the invention of the manager of the company, Mr. T. T. Heaton, and when it is remembered what obstacles had to be overcome in creating a market for steel barrels, the prejudices to be fought against, and the somewhat unscrupulous competition encountered from certain foreign imitators, the progress achieved is little short of marvellous.



Petrol Storage Plant of the Steel Barrel Co. Ltd.

The Steel Barrel Co. commenced operations in 1897, and were the first to produce a barrel made of steel which possessed the peculiar advantages of a wooden barrel, yet rendered it superior in all respects to the latter, and at the same time made its use possible for purposes for which the wooden barrel is quite unsuited. Eight years later the company's works were considerably extended in order to cope with the rapidly expanding business, and to provide facilities for the production of new lines. To-day, the works are, in many ways, a model of their class, with excellent facilities for rail and water transport. The company have developed the most modern systems of welding, which include electric-arc welding, electric contact welding, oxy-acetylene and

autogenous welding, each method producing in infinite variety such articles for which it is best suited.

It is unnecessary to enumerate the variety of purposes for which these barrels are used in all parts of the world, but it is worth mentioning that the company is alone in manufacturing cylindrical drums with rolling hoops fixed on by means of welding. This, of course, obviated the common trouble encountered in this form of drum, as ordinarily made, namely, the slipping out of position of the hoops.

These barrels naturally led up to the development of a method of petrol storage in bulk, and it is with the apparatus for this that we are mainly concerned at the moment.

petrol storage and measurement is exceedingly simple. The spirit is stored in an underground welded-steel tank, which is provided with manhole and galvanised-steel cover fixed by bolts screwed in the top of the tank from below and nuts outside the cover, with an asbestos washer coated with shellac varnish to make the joint tight. A filling-pipe (shown at A in Fig. 1) extends to within about 4 in. of the bottom of the tank to avoid vaporising the spirit, the lower portion being 2 in. diameter, and the upper portion $2\frac{3}{4}$ in. diameter inside. The upper portion is fitted with a brass wire gauze strainer, and strong, perforated galvanised iron protector inside it, which are fixed into the filling pipe by means of a screw, to make a water-tight joint. The actual point of filling

View of one of the Shops of the Steel Barrel Co. Ltd.

With the growing employment of commercial motor vehicles in the textile industry, the problem of storing petrol has an important interest for the millowner. The provision of suitable storing and measuring apparatus which shall combine absolute accuracy of measurement with proof against being tampered with has exercised the utmost care on the part of the Steel Barrel Co., with the result that they have produced a system which embodies both these requirements, and which, by its efficient, reliable, and economical working, has gained for bulk storage that favour among owners of commercial motor-vehicles which inferior American products tended to impair.

The arrangement of the Steel Barrel Co.'s system of

is above ground to prevent risk of water entering. A gun-metal cap with leather washer closes the top of the filling pipe, and if necessary this can be arranged so that the hose-pipe accompanying the road tank-wagon can be screwed on, thus filling the storage tank under seal. Where the circumstances do not permit of supply by tank-wagon the company provide an arrangement by which the same pump that is used for the measuring tank can be made to pump from steel barrels into the filling pipe of the storage tank.

For gauging the quantity of petrol in a storage tank a 1-in. pipe is fixed into the cover of the manhole, and by means of a dipping rod the quantity of spirit can be shown in the tank.

The measuring tank B is stamped as a correct measure by the weights and measures authorities approved by the Board of Trade. The spirit is raised into this tank by means of a semi-rotary pump C, with a pump pipe extending to about 4 in. from the bottom of the storage tank, and furnished with a foot valve and strainer. There is also a valve between the pump and the measuring tank. To prevent over-filling the latter, an overflow pipe D is arranged at the side, so that if too much be pumped in the surplus will run back into the storage tank. The apparatus is provided with a padlock and key, so that no unauthorised person can obtain spirit.

Filling Tank on a Motor Vehicle from one of the Steel Barrel Oil Plants.

Road Tank Wagon Filling an Underground Tank.

For measuring the quantity of spirit distributed, the measuring tank is fitted with top and bottom gauge cocks, with a protected glass tube having a red line to enable the spirit to be distinctly seen. A steel scale, graduated in gallons, is fixed to the measuring tank close to the side of the glass tube. A by-pass arrangement is provided so that when the apparatus is not in use the measuring tank and practically all the pipes above ground can be drained back into the storage tank by pushing the handle of the pump C (which is of the self-emptying type) hard over, and so opening the valve therein. On opening the valve in the by-pass pipe the spirit runs back through the overflow pipe into the storage tank. A vent pipe is taken from the top of the storage tank and another from the top of the measuring tank to the open air G, the end of each being bent over and provided with a bell-mouth opening, covered with brass wire gauze to prevent fire risk.

For distributing the spirit there is a control cock E in the side of the measuring tank for controlling the distribution, and attached to this cock a flexible armoured hose F, capable of giving a very wide area of delicacy, which terminates with a $\frac{3}{4}$ in. full-opening gunmetal valve and nozzle.

Long experience has demonstrated what a careful personal examination made obvious, that from these plants there is no leakage and no waste. Spirit is handled cleanly and rapidly, and can be bought much more cheaply in bulk than in tins. Therefore, much money is saved in a garage fitted with one of the Steel Barrel Co.'s plants, and the risk of fire is eliminated. Thus, the only objection that might be raised against the storage system, *i.e.*, relating to the accuracy of and proof against tampering with the self-measuring apparatus is eliminated by the effective means which the Steel Barrel Co. have provided to ensure the safe and economical working of the system. That this is not always the case is evidenced by a United States official report, which mentioned that a very large percentage of American apparatus, when examined by the public officials, were found to be very much against the user.

## TRIALS ON A DIESEL ENGINE, AND APPLICATION OF ENERGY-DIAGRAM TO OBTAIN HEAT BALANCE.*

By the late Lieut. F. Trevor Wilkins (Northumberland Fusiliers), M.Sc., of the University of Birmingham, Graduate.

### Introduction.

The following paper contains a description of some trials carried out on a small Diesel engine in the power station at the University of Birmingham. The manner of conducting these trials and of working out the results enables the author to present additional figures to those usually given in descriptions of similar investigations. The indicator diagrams obtained in the present trials were re-drawn upon a heat-energy chart, and by this means any differences between the theoretical and practical cycles are clearly exhibited. Among the chief points of interest derived from this method of procedure were the following:—

(1) The amounts of heat passing to the cylinder walls and to the exhaust were accurately determined. The heat flow during the compression and expansion strokes was separately estimated; also in each case the period during which this heat flow takes place was definitely indicated.

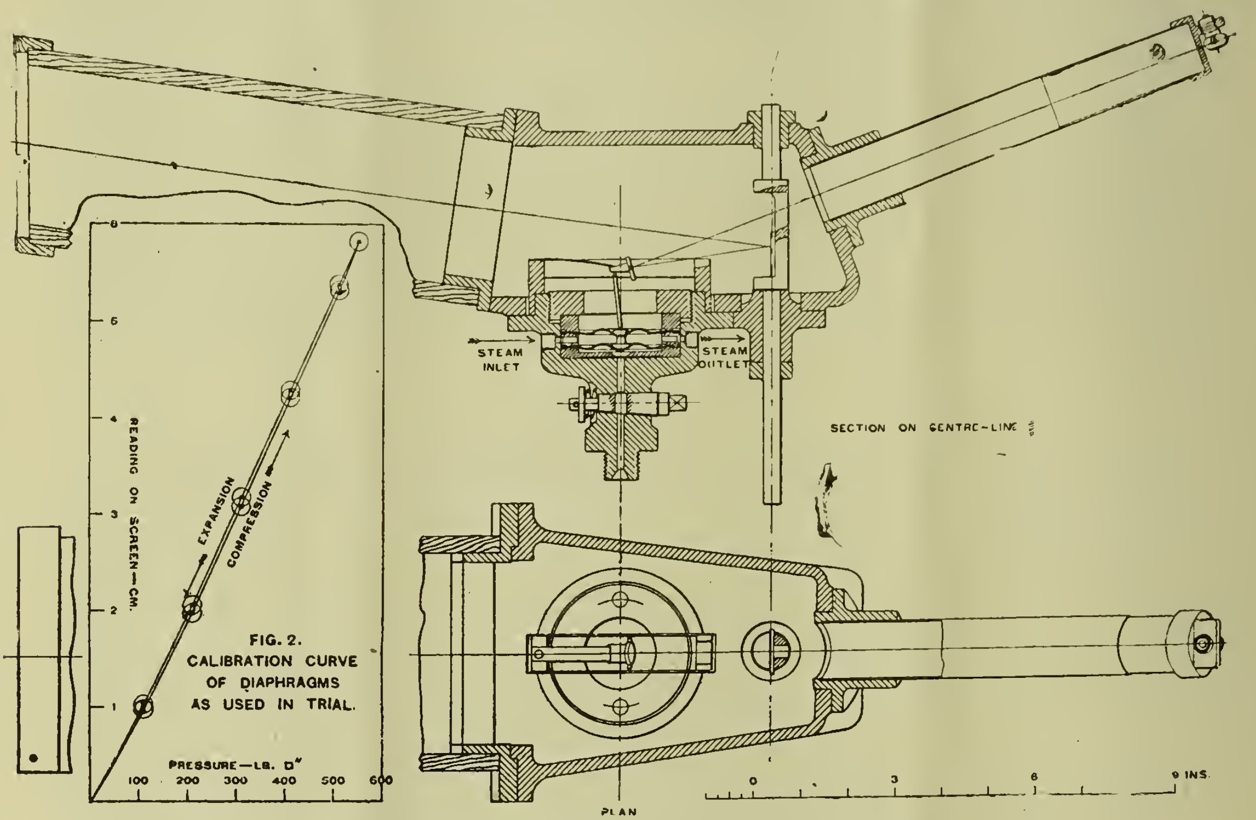


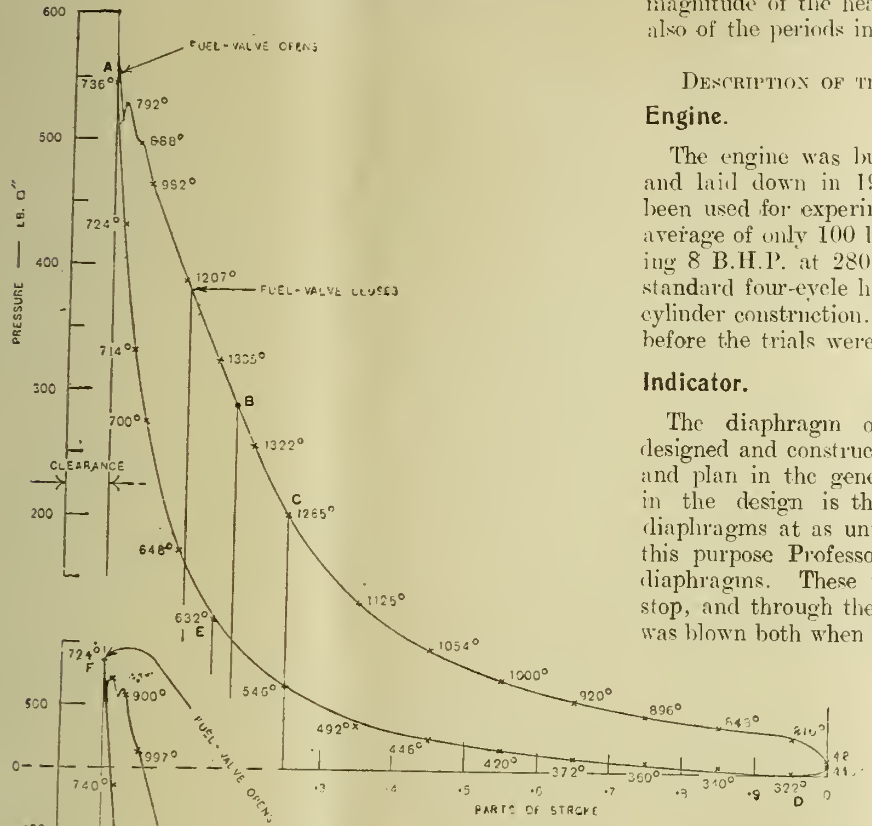

FIG. 2.
CALIBRATION CURVE
OF DIAPHRAGMS
AS USED IN TRIAL.

Fig. 1.—General Arrangement of Diaphragm Optical Indicator.

* Paper read at the meeting of the Institution of Mechanical Engineers, on October 20th, 1916.

(2) Curves can be shown giving the temperature in the engine cylinder at any point during compression and expansion and an accurate heat balance sheet drawn up.

Fig. 3.—Full Load Mean Indicator Diagram.
M.I.P. = 86·15 lb. square inch.
Temperatures in degrees Centigrade absolute.



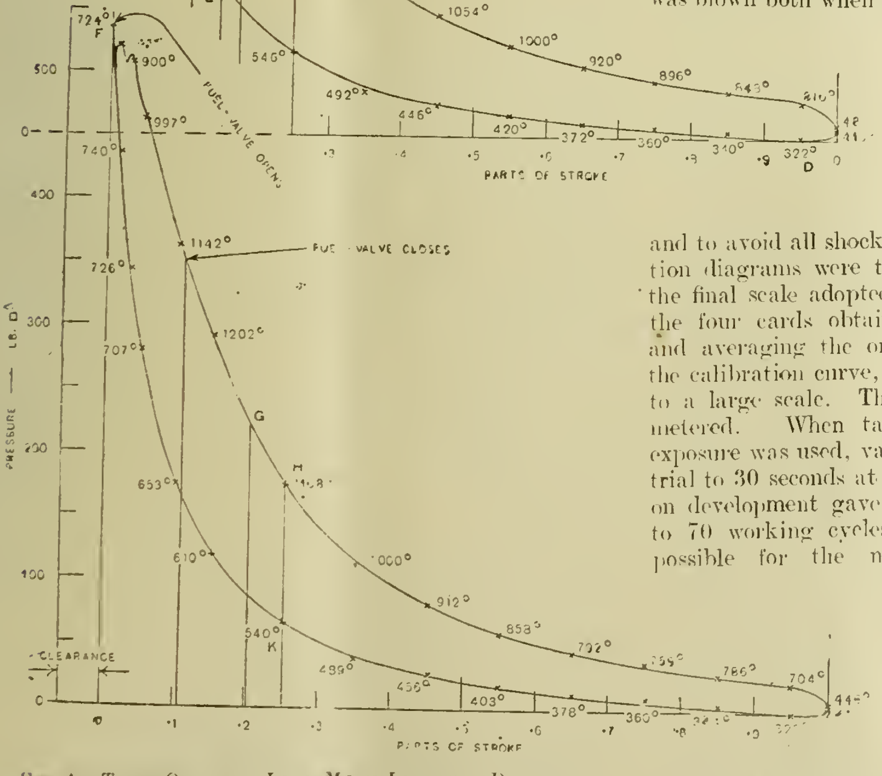




Fig. 4.—Three Quarters Load Mean Indicator Diagram.
M.I.P. = 70·35 lb. square inch.
Temperatures in degrees Centigrade absolute.

## Summary of Method.

All charge quantities entering the engine cylinder were accurately measured; on the other side of the balance sheet precautions were taken to obtain an accurate indicator diagram. From these sources the volumes and pressures of cylinder charges of known weight and composition were estimated, enabling the indicator diagram to be transferred to Professor Burstall's "Energy Diagram for Gas."* On this diagram the internal energy and temperature at any point in the cycle may be read off directly, thus making it possible to obtain a fairly approximate idea of the magnitude of the heat flow through the cylinder walls, and also of the periods in the cycle in whihc it takes place.

### Description of the Apparatus Used in the Trials.

## Engine.

The engine was built by the Maschinenfabrik Augsburg and laid down in 1906. Since that date it has entirely been used for experimental purposes, probably running an average of only 100 hours per year. It is rated as developing 8 B.H.P. at 280 revolutions per minute, and is of the standard four-cycle heavy cast-iron A-frame vertical single-cylinder construction. The cylinder dimensions as measured before the trials were 10·61 in. stroke and 6·50 in. bore.

## Indicator.

The diaphragm optical indicator, Fig. 1, expressly designed and constructed for these trials, is shown in section and plan in the general arrangement. The novel feature in the design is the means adopted for keeping the diaphragms at as uniform a temperature as possible. For this purpose Professor Burstall suggested the use of two diaphragms. These were connected at their centres by a stop, and through the space between the diaphragms steam was blown both when running engine tests and in calibrating the scale of the diaphragms, Fig. 2.

The indicator was calibrated immediately before and after each trial. A Crosby dead-weight gauge tester was employed, care being taken to move the weight gently and to avoid all shock when altering the load. Two calibration diagrams were taken before and after each test, and the final scale adopted was the mean of those furnished by the four cards obtained. After scaling up the diagram and averaging the ordinates, the pressures were read off the calibration curve, and a mean indicator diagram drawn to a large scale. This diagram was then carefully planimetered. When taking indicator cards, a rather long exposure was used, varying from 15 seconds in the half-load trial to 30 seconds at full load, Fig. 3. The trace obtained on development gave, therefore, a mean card of from 35 to 70 working cycles. These long exposures rendered it possible for the number of cards taken during a test to be reduced to four only, but there were sufficient to represent from 140 to 280 cycles. For purposes of comparison the approximate area of each diagram was ascertained by finding mean heights, etc., and the greater percentage differences obtained between the individual diagrams of a test were $1\frac{1}{2}$ per cent in the case of the full-load diagrams, 2 per cent at three-quarter load, and 3 per cent at half load.

*(To be continued.)*

* Proceedings, I.Mech.E., 1911, page 171.

# THE NEW COALFIELD IN WEST AFRICA.*

In 1903, on the suggestion of the Director of the Imperial Institute, a mineral survey was organised to examine the mineral resources of Southern Nigeria. The object of this survey was, in the first place, to obtain general information as to the probable mineral resources of the country and then to study in greater detail those areas which were found to contain minerals likely to be of economic importance. With this object in view, it was arranged that two surveyors, selected by the Director of the Imperial Institute and trained in field geology and mining, should visit Southern Nigeria each year and carry out a definite scheme of exploratory work in selected areas. In the course of this work the surveyors collected representative samples of all minerals of economic importance, and these were forwarded to the Imperial Institute for mineralogical and chemical examination, commercial valuation, and suggestions for development. From time to time reports of progress were made to the Government on the field work done in Southern Nigeria and on the results obtained at the Imperial Institute. Summary reports of these results, chiefly intended to direct attention to the economic aspects of the work, have been presented to Parliament and published in the "Miscellaneous Series of Colonial Reports." The survey was continued until 1913, and in the period 1903-13 nine of these summary reports of results were published.

One of the most important results obtained in the course of the survey was the discovery of large deposits of lignite and coal. Large lignite or brown coal deposits were found on both sides of the river Niger near Asaba, but this material was completely overshadowed in its importance as a fuel by the subsequent discovery of a great coalfield named the Udi-Okwoga coalfield, from the names of the native villages at its known southerly and northerly limits. The total area of the coalfield as at present determined is about 1,800 square miles.

The existence of coal in this area was first noted by the surveyors, Messrs. A. E. Kitson and E. O. Thiele, in 1909, and the work of determining the area of the field by the observation of outcrops, and later on by boring trials, was continued by these officers and by their successors, Messrs. A. D. Lumb and M. Whitworth, until the close of the survey in 1913.

As the Government of Nigeria is the chief consumer of coal in the country for the use of the Government railways, the development of the coalfield has been undertaken by the Public Works Department, and, as shown later on, the working of the coalfield has already reached an important stage.

Now that a railway has been built from Port Harcourt to the best-known part of the coalfield the resources of this area have assumed a still greater importance, and it is proposed in this article to give a general account of the coalfield and of its recent development.

## Geological Features of the Coalfield.

The youngest rocks of the Udi region are loose detrital sediments, consisting of reddish sands. These occur at the surface, are very variable in thickness, and are regarded as belonging to the Benin Sand series, which is of comparatively late Tertiary age.

These superficial sands lie unconformably on cretaceous strata, which are made up chiefly of sandstones, shales, and mudstones. It is in these cretaceous beds that the coalseams are found. The cretaceous strata extend over a raised plateau region for a distance of some 80 miles, stretching northward from the Udi district to the Okwoga district. The plateau surface rises somewhat towards the north, and attains a height of over 2,000 ft. It slopes gradually to the west, and is not more than 200 ft. or so in height along the Oji River. The plateau is bounded on the east by a scarp in which outcrops of coal are found. A line of outcrops stretches along this escarpment northwards from near the source of the Mamu River, south of Udi, to Otukpa north-west of Okwoga.

The cretaceous beds are almost horizontal. On the whole there is a slight westerly dip, so that to the west of the above-mentioned scarp the coal occurs at some depth from the surface. A boring made at a locality to the west of Udi and 32 miles from Onitsha revealed two seams of coal at depths of $40\frac{1}{2}$ ft. and $82\frac{1}{2}$ ft. respectively. In another boring still farther west, and 17 miles east of Onitsha, coal was found at a depth of 115 ft. Farther north coal outcrops have been observed as far west as the Iyokolla River, which is a few miles east of Ogrugru, and near the Anambra River.

## Nature of the Coal.

The Udi coal is of the sub-bituminous type, and usually of a dull-black appearance, though some of the seams show alternating bands of dull and more lustrous coal. The specific gravity varies, and for material not containing more than about 15 per cent of ash the value ranges from about 1·16 to 1·32, with an average of about 1·23.

As a rule the coal is fairly free from mineral impurity, but occasionally it contains nests and films of amorphous clayey matter and pyrites. Films and patches of chalybite and kaolinite occur as infillings of the joint cracks and small crevices in the coal.

The coal ignites readily, and burns with a bright, steady flame, giving off only a small amount of smoke. It does not cake or decrepitate on heating. The ash is usually white or light grey, and practically free from clinker.

An analysis of a typical specimen of the coal taken from the 5-ft. seam now being developed gave the following result:—

| | Per cent. |
|---|---|
| Fixed carbon | 48·41 |
| Volatile matter | 38·18 |
| Ash | 7·79 |
| Moisture | 5·62 |
| | 100·00 |
| Sulphur | 0·76 |
| Calorific value,* small calories | 6969 |

*(To be continued.)*

* From Bulletin of Imperial Institute.'

* The calorific value represents the number of grams of water which would be raised from 0° to 1° C. in temperature by the combustion of 1 gram of the coal.

The Calcutta Electric Supply Corporation Limited.—The London correspondent of this corporation reports that the number of units sold to consumers during the five weeks ended September 29th, 1916, were 2,699,816, compared with 2,612,755 in the corresponding five weeks of 1915. The number of units sold to consumers during the four weeks ended October 27th, 1916, were 2,038,767, compared with 1,889,945 units in the corresponding four weeks of 1915.

# ELECTRICAL ACTIVITIES AFTER THE WAR.

By F. Ashton.

The crisis through which we are now passing has naturally set back electrical progress, and it is to be hoped that when hostilities are ended no time will be lost in restoring certain branches of this important industry. But whilst it is true that electrical supply undertakings have suffered more or less severely as a result of the lighting restrictions, it is common knowledge that the power loads have in some cases increased considerably. In the industrial centres the demand for electric power is at the present time great, and although the lighting loads of many of the large stations have diminished, the plants are nevertheless turning out more units than they did prior to the war. It is pretty certain that when normal conditions are restored many manufacturers who have put down motors to cope with the present heavy demands upon their factories will have discovered that electric driving offers advantages, and a large permanent increase in the use of electric power is to be expected. But in other directions vigorous propaganda will be needed. Two years ago there was, for instance, a rapidly-growing demand for electric vehicles. Large business concerns were beginning to use these vehicles for the delivery of their goods and electric omnibuses were also making headway in certain parts. It would be wrong to assert that all progress in this direction has stopped, for, as a matter of fact, a good deal has recently been done, especially in connection with the supply of electric trucks for the transportation of munitions; although, of course, the business as a whole has not been nearly so brisk as it would have been under normal conditions.

The electric road vehicle has undoubtedly a great future before it. As a result of the use of improved storage batteries, the cost of running these vehicles has been considerably reduced, and the old troubles which were met with in the early days are no longer prevalent. For certain businesses in which cleanliness is of vital importance this type of vehicle has much to recommend it; in fact, for the delivery of milk and delicate goods there is nothing to equal it. Experience has shown, moreover, that from the point of view of running and maintenance costs, a vehicle propelled by modern storage batteries is infinitely superior to one propelled by a petrol engine. Doctors, commercial travellers, and others who have to travel about daily, will undoubtedly make extensive use of these vehicles in the future. After the war this is a branch of the electrical industry that will have to be developed with even greater energy than before. It promises to supply central stations with a valuable source of revenue, and considerably to improve the load factor. An electric vehicle load is valuable for the reason that the batteries can be charged at night when many generating stations are now more or less idle. What is wanted to foster the electrical vehicle industry is the provision of adequate charging facilities. Public electric garages where vehicles can be left and charged overnight will no doubt be provided in due course, and when normal conditions are restored this is a matter which electricity supply authorities ought to look into. Of course, some of the large business concerns in London that are now running electric vehicles have their own charging plants, but doctors and others possessing only one vehicle and storing in public garages will want to have the cells charged outside. It is to be remembered that even if access can be had to an electric supply circuit a charging equipment of some kind is almost sure to be necessary. If the supply be a continuous-current one the pressure will probably be much above that of the battery, and if it be an alternating-current one the current will, of course, have to be converted or rectified. Leaving aside the question of using resistances for pressure reduction, which are very wasteful, it will be seen that on continuous-current circuits a motor generator will be needed, whilst if the supply be an alternating-current one, use must be made of either a motor generator or mercury vapour rectifier. It is unlikely, therefore, that those who run only one or two vehicles will want to charge the batteries at home.

Upon the provision of electric garages the progress of the electrical vehicle industry greatly depends. Though it is improbable that vehicles propelled by storage batteries will ever be used for long journeys, it is nevertheless essential that adequate charging facilities should be provided in every city and town. The electric vehicle committee that was established soon after the movement was set on foot in this country has done excellent work in the way of standardising voltages, charging plugs, etc. Nothing could be more fatal to the movement than diversity in such details. For an electric vehicle to be serviceable it should be capable of being charged anywhere where charging facilities are provided. Want of conformity in voltages and other details was a great drawback in the early days of the electric launch on the River Thames, and it is very fortunate indeed that a body of far-seeing men have had the good sense to form a committee with a view to drawing up recommendations in connection with this new industry. Of course, in America and on the Continent of Europe the electric vehicle is much more popular than it is here. Early experiences in this country caused it to be viewed in a very unfavourable light. The batteries are altogether unsuitable for the purpose, and the general design of other parts also left much to be desired. Owing partly to the evolution of new batteries constructed on totally different lines to those used in the past and partly to specially-constructed motors and control gear, all difficulties have been removed, and battery-propelled vehicles are now thoroughly reliable. Had it not been for the war it is pretty certain that so far as London is concerned the use of this type of vehicle would now be rapidly increasing, and it is to be hoped that when manufacturers are again free to engage in their ordinary pursuits every endeavour will be made to make up for lost time.

The possibility of creating electric cooking loads is another matter that ought to be looked into. A well-known electrical engineer pointed out some time ago that if every householder now using electric light were to cook by electricity as well, the consumption per house would be increased by at least 400 per cent: that is to say, an undertaking now supplying five million units per year for domestic lighting can by developing a cooking load raise the output to at least 25 million units per year. It would, of course, require a very exceptional man to persuade every lighting consumer to cook by electricity, but there is no reason why the cooking loads of many central stations, especially those that supply current to wealthy residential areas, should not be much greater than they are. At present electric supply undertakings depend for their output on two classes of demand—the demand for light and the demand for power. It is only within recent years that some undertakings have endeavoured to get their consumers to use electricity for cooking and heating. Up to the present only a few central station engineers have made a thorough study of this matter, but, of course, it is a matter that mainly concerns engineers who are in charge of stations that supply current to large residential areas. To

be successful in this connection current must be supplied at low rates. Until consumers can be convinced that the cost of electric cooking is not excessive nothing very startling is likely to be done. A fair number of electrical engineers who have not thoroughly investigated this matter appear to be under the impression that the cost of electric cooking is much greater than actual experience shows. An engineer associated with one of the London stations dealing with a fair cooking load has, as the result of careful observation, come to the conclusion that with current at 1d. per unit and gas at 2s. 6d. per 1,000 cubic feet, the cost of cooking is in each case practically the same. It is difficult, however, to make a satisfactory comparison, for it has been found that when an electric cooker is installed in place of a gas stove the former is called upon to do much more work than its predecessor. A number of operations done in the coal range (for which the gas cooker was never used on account of its unsatisfactory working in the hands of the average cook) are all carried out on the electric cooker as soon as it is available, because of the excellent results obtainable. It has been found that the average current consumption for a family of eight persons in full and constant occupation of a house in which all the cooking is done by electricity, and water for baths and washing purposes heated by other means, works out at 1·9d. units per person per day. This figure, however, has been arrived at from observations made in a well-to-do residential area where cooking is carried out extensively. The consumption of a middle-class house usually ranges from one-half to one unit per person per day. Here, then, is another matter that must be dealt with with renewed vigour after the war. Electric cooking is not by any means a new idea. Much has been written and said about it at different times, but only a few central station engineers have taken the matter up seriously. For a long time past the use of electricity for purposes other than those of lighting and power has been steadily increasing. Cleanliness and convenience are the main advantages it offers, and when householders are convinced that electric cooking and heating are not unduly expensive there will undoubtedly be a big increase in central station loads.

*(To be continued).*

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertiou of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

"SOME" LUBRICATION.

*To the Editor of "The Industrial Engineer."*

Sir,—Referring to your interesting paragraph on page 89 of December 8th, the undersigned has been informed by a user of a correspondingly quite as good performance in the case of a double-crank enclosed self-lubricating engine 8 in. and 10½ in. by 6 in. stroke, which in about 3½ years ran, in round numbers, about 450,000,000 revolutions, and required less than 50 gallons of oil, giving 9,000,000 revolutions for one gallon of oil for all purposes, cylinder lubrication as well as crank chamber. In this case, taking about 1½ in. as the distance over the piston rings, and which therefore is to be added to the length of stroke, making 7½ in., the surface travelled over by rings in the cylinders alone, without main bearings, crank pins, guides, etc., is fully 6 square feet per revolution, thus the total cylinder surface is 54,000,000 square feet for one gallon of oil. If the other working surfaces were added there would be at least one-third additional surface traversed. This engine, however, had the advantage of being vertical, and also the gauge pressure was only 80 lbs. and no superheat.—Yours faithfully.

W. Sisson.

Gloucester, 14th December, 1916.

# New Companies Registered.

BRITISH COMPRESSED AIR PUMPS LTD. (145,352).—Private company. Registered November 21st. Capital, £2,500, in 2,000 ordinary shares of £1 each and 10,000 deferred shares of 1s. each. To carry on the business indicated by the title and that of engineers, manufacturers of machinery, tool, boiler and cylinder makers, founders, shipbuilders, etc. Directors: E. A. Enever and F. H. Bailey (both permanent, subject to holding one share each). Solicitor: E. A. Fuller, 5, Clements Inn, W.C.

E. T. NEAL AND CO. LTD. (145,398).—Private company. Registered November 27th. Capital, £4,000, £1 shares. Engineers, founders, metal casters, and workers, wheelwrights, shipbuilders, motor engineers, etc. Directors: E. T. Neal and J. S. Burton (both permanent). Qualification £250 shares. Solicitor: W. Bryan, 16, Dalkeith Place, Kettering. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

AFTON ENGINEERING CO. LTD. (145,429).—Private company. Registered December 1st. Capital, £30,000, £10 shares (1,500 preferred). To take over the business connection of R. Craig-McKerrow, engineer, railway equipment and supply contractor and merchant and agent. Directors: V. Woods (chairman), R. Craig-McKerrow (managing director), and W. L. Lyon Clark. Qualification, £250. Remuneration of managing director not less than £600 or more than £2,000 per annum in any year, and he shall be entitled to have allotted t ohim one deferred share for every preference share issued; of other directors three guineas each per meeting attended. Registered office: Dacre House, Dean Farrar Street, Westminster.

FRIEDENTHALS LTD. (145,448).—Private company. Registered December 4th. Capital, £6,000, £1 shares. To take over the business of a pump and propeller maker and general engineer carried on by F. Friedenthal at Brieryfield Road, Preston. Directors: F. Friendenthal, senr., F. Friedenthal, juur., and A. Friedenthal (all permanent, subject to holding £250 shares each). Solicitor: P. J. Ramsbottom, 48, Lune Street, Preston. Registered by Jordau and Sons Ltd., 116-17, Chancery Lane, W.C.

JOHN WIGHAM AND SONS LTD. (145,421).—Private company. Registered November 30th. Capital, £25,000, £1 shares (5,000 preference). To take over the business of engineers, ironfounders, and ship repairers formerly carried on by J. Wigham and J. R. Wigham at South Hylton, Durham, as John Wigham and Son. Directors: J. Wigham (chairman), J. R. Wigham, J. T. Wigham, and S. Wigham (all permanent). Qualification, 100 ordinary shares. Solicitor: J. F. Burnick, 65, John Street, Sunderland. Registered office: South Hylton Engine Works, South Hylton, near Sunderland.

PEGASUS AIRCRAFT CO. LTD. (145,413).—Private company. Registered November 29th. Capital, £1,000, £1 shares. Consulting, manufacturing, mechanical and general engineers, manufacturers of aeroplanes, hydroplanes, airships and motor cars, or boat propellers, engines and component parts and accessories of all kinds, etc. Table "A" mainly applies. Solicitor: H. H. Olley, Broad Court Chambers, Bow Street, W.C. Registered by R. Warner, 10, Walbrook, E.C.

BEN NEVIS ENGINEERING CO. LTD. (9,706).—Private company. Registered in Edinburgh on November 23rd. Capital, £2,000, £1 shares. Engineers, ironfounders, etc. To take over the business of the Ben Nevis Machine Co., at 10, Renfrew Lane, Glasgow. Directors: G. B. Arcari, C. Cola,, and C. Fusciardi. Qualification five shares. Solicitor: A. Milne, Glasgow. Registered office: 10, Renfrew Lane, Glasgow.

## FOREIGN (ENEMY) FIRMS.

ROCHESTER ENGINEERING CO. LTD., Rochester, Kent, engineering company making machinery for cement works. Controller: A. Dangerfield, 56, Cannon Street, E.C. (Nov. 17th—366.)

VINCIT COMPANY LTD., Apollo Works, 21, South Road, New Southgate, N., agents for the sale of carborundum and electric machinery. Controller: Charles Eves, Capel House 62, New Broad Street, E.C. (Nov. 29th—373.)

# Trade Items, Notes, &c.

Floating Dock.—The Copenhagen Floating Dock and Shipbuilding Company has secured a site of 70,000 square miles for extending the works; for this purpose the capital is being increased by 1,000.000 kronen to 3,000,000 kronen.

Bearing Alloys.—Among the various alloys introduced for bearings is the following: Cadmium, 45 per cent; zinc, 45 per cent; antimony, 10 per cent. This was the subject of a German patent, and was claimed to have a very low coefficient of friction and to cast well.

Austrian Ironworks.—The Austrian ironworks delivered in September bars and sections, 57,415 tons, as compared with 41,428 tons in 1915; girders, 6,603 tons, as against 6,920 tons; heavy plate, 9,684 tons, as against 3,938 tons; and rails, 7,370 tons, as against 6,245 tons.

Locomotive Orders.—The Russian Government has, it is stated, finally distributed orders for 100 of the 1,000 locomotives for which inquiries have been made. It is believed that 40 will be built by the American Locomotive Company, 40 by the Baldwin Locomotive Company, and 20 by the Canadian Locomotive Company.

The Ontario and Niagara Connecting Bridge Company is to build a bridge of steel and concrete over the Niagara at Niagara Falls. The bridge is to be available for steam and electric railways, vehicles, and pedestrians; its cost is estimated at £200,000. The structure will span the Niagara near a point at which the transmission line of the Niagara, Lockport, and Ontario Power Company crosses the rapids.

Manganese in the United States.—The imports of manganese into the United States in August were 76,721 tons, as compared with 81,942 tons in July. The total imports for the eight months ended September 1st, 1916, were 395,686 tons, as compared with 145,003 tons in the first eight months of 1915, and 183,029 tons in the first eight months of 1914. American manganese ore imports are now considerably in excess of those of Great Britain.

An alloy has been produced which is claimed to be an entirely satisfactory substitute for platinum, either as crucibles or as ignition tubes, thermo couples, etc. The new material is called rhotanium, and is reported to be an alloy of metals of the platinum group. The price of the new alloy is the same as that of platinum, but its specific gravity is about half that of platinum. It was discovered by Frank A. Fahrenwald, of Cleveland, Ohio, and is being manufactured by the Industrial Research Corporation of that city.

All-iron Railway Trains.—Steel carriages, long known in America, have recently been introduced into Germany. The first all-iron D (express) train has been running since September between Berlin and Cologne. It consists of five passenger carriages and a dining car. The carriages were all built by Messrs. Van der Zypen and Charlier, of Köln-Deutz; the bogies are of the Othegraven type and are said to run very smoothly. Wood is used only for the panelling of the walls and for the flooring.

American Locomotive Building.—Orders for 30 engines have been placed with the Baldwin Locomotive Works; of these 20 Pacific and five switching locomotives are for the Atlantic Coast line. The number of locomotives ordered in October was no less than 779; this was the largest total reached in any month this year. The orders received for locomotives in the first four months of the second half of 1916 comprised 1,271 locomotives; this compared with 2,124 engines ordered in the first six months of the year. In 1915 the number of locomotives ordered was 1,972.

Glass Manufacture.—A department of glass technology at the University of Sheffield has, says *The Times,* been organised with the financial support of the Advisory Committee of the Privy Council for Industrial Research, of the Ministry of Munitions, and of the glass manufacturers of South Yorkshire. An actual glass factory will be established, in which operations will be done on a large, semi-commercial scale. The model factory will be equipped with pot furnaces and a small tank furnace and a series of experimental furnaces, including a number of electrically-heated ones and some heated by gas.

Russian Metallurgy.—The production of pig iron in Russia last year was 4,062,100 tons, as compared with 4,769,300 tons in 1914. The output of semi-finished steel was 4,539,100 tons, as compared with 5,508,800 tons, and that of finished steel 3,599,500, as compared with 4,334,100 tons. Of the semi-finished and finished steel 60 per cent was produced in Central Asia, while the Ural region made 20 per cent. Of the pig-iron made in Russia last year rather more than 70 per cent was produced in Central Russia.

Coke Fuel for Electric Power Stations.—The Highways Committee of the London County Council have placed an order for eight coke-burning mechanical stokers for use under the steam boilers at the Greenwich generating station. It is calculated that the first sets of stokers now contemplated will, if worked to their full capacity, consume 100 tons of coke per 24 hours; and having regard to the relatively high cost of coal, as well as the relatively greater degree of efficiency attainable in burning coke, every effort will, no doubt, be made to use the new stokers to their fullest capacity.

Copper and Brass for Munitions.—The Minister of Munitions, in pursuance of the powers conferred upon him by the Defence of the Realm Regulations, has issued orders that every person engaged in the production of brass rod tubing, sheet and wire strip, stampings, castings, billets and ingots, and copper rod and wire, tubing, sheets, plates, discs, and ingots, shall furnish to the Director of Materials particulars of his output in such form and at such times as shall from time to time be notified to him by the Director of Materials. The Minister of Munitions further orders that any particulars so furnished shall be verified by the signature of the person required to furnish them, or where such person is a firm or company, by the signature of a partner, director, or other responsible officer.

An Aerial Tramway in California.—One of the most remarkable tramways in the world, according to *Popular Mechanics*, is the aerial line used to convey salt from the Saline Valley in California. These salt deposits are situated in an extremely desolate district. It was formerly necessary to carry the salt in wagons, which took 13 days to cover the distance over an almost impassable road. To-day buckets, each carrying 700 lbs. of salt, are conveyed on wires over the same distance in about two hours and 20 minutes. The line is 13½ miles long. It ascends to a height of 6,000 ft. to 7,000 ft., and at one point the line ascends 1,950 ft. in a distance of 4,400 ft.

Wireless Telegraphy on Aeroplanes.—According to American reports, says the *Wireless World*, what is claimed to be a record in wireless telegraphy from aeroplanes was recently established by Captain Culver, of the United States Aviation Corps. During a flight from San Diego to Santa Monica, 114 miles away, he is stated to have kept in touch with his station by sending wireless messages every three minutes. The power for the transmission set is derived from a generator placed on the lower wing section of the aeroplane, and is driven by a two-bladed propeller. Aerial wires are suspended from the "fuselage" of the machine with an insulated counterpoise hung from the wings to the tail of the aeroplane. The complete transmission set is stated to weigh less than 40 lbs.

British Capital in Canada.—The flow of British capital to Canada has been on a considerable scale during the last ten years although a sharp contraction was experienced in 1915 and 1916. The yearly totals come out as follows:—

| Year. | Amounts. £ | Year. | Amounts. £ |
|---|---|---|---|
| 1907 | 11,203,711 | 1912 | 32,456,600 |
| 1908 | 29,354,721 | 1913 | 47,363,425 |
| 1909 | 37,411,723 | 1914 | 37,777,271 |
| 1910 | 38,453,808 | 1915 | 8,325,000 |
| 1911 | 39,855,517 | 1916 | 1,000,000 |

The war rapidly reduced the volume of British-Canadian investments, which during the past 12 months have been almost at an end. It will be seen that the record year was 1913; in the last five months of 1914 the war greatly restricted Canadian investments, which were further reduced in 1915. The aggregate investments of British capital in Canada are estimated at present at £582,829,000. At the close of 1913 American capital had also been placed in Canada to the extent of £636,903,952.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS.

**November 27th to December 2nd (inclusive).**

Adams, C. H.: Screening-apparatus. 17,169.
Akt.-Ges. Brown Boveri, et Cie: Latching-devices for electro-magnets. 17,060.
Akt.-Ges. Brown, Boveri, et Cie: Alternating-current magnet and its armature. 17,061.
Akt.-Ges. Brown, Boveri, et Cie: Time-limit relays. 17,334.
Akt.-Ges. der Maschinenfabriken Escher, Wyss, et Cie.: Annular footstep bearings. 17080.
Berriman, A. E.: Internal-combustion engines. 16,985, 17,008.
Berriman, A. E.: Carburettors. 17,195, 17,196.
Bjornstad, J.: Turbine centrifugal pumps. 17,015.
Blakeborough, R. A.: Reducing valves. 17,259.
Boye, F. L.: Motors. 17,121.
Bradshaw, G. E.: Petrol-engine bearings. 17,019.
Bradshaw, G. E.: Couplings for propellers. 17,021.
Bridge, J.: Hydraulic presses. 17,309.
Broadhead, J. B.: Reducing valves. 17,259.
Buchanan, J.: Pistons. 17,248.
Bullivant's Aerial Ropeways Ltd.: Rope runways. 17,145.
Butcher, C. A.: Valve-gear. 17,024.
Campbell, A. J.: Governors, valves, gates, 17,261.
Campbell, T. B.: Governors, valves, gates. 17,261.
Constantinesco, G.: Wave transmission of power. 17,130.
Coombes, W.: Toothed and chain gearing. 16,971.
Cooper, T. L. R.: Electric motors. 17,292.
Cromwell, O.: Pistons. 17,013.
Curtis, H.: Utilising tidal, &c. power. 16,967.
Daimler Co.: Internal-combustion engines. 16,985.
Daimler Co.: Carburettors. 17,195. 17,196.
Douglass, A. E.: Making briquettes. 16,962.
Driver, A. S.: Carburettors. 17,033.
Edwards, M.: Pumps. 17,301.
Elliott, A. G.: Pipe clips. 17,156.
Enzer, J.: Internal-combustion engines. 16,936.
Ford, A. E.: Silencing exhaust from internal-combustion engines. 17,228.
Frewen, E. J.: Converting hydraulic pressure into energy. 17,177.
Gee, W. J.: Variable-speed gears and clutch. 17,067.
Gill, T. H.: Joints and connections for pipes or tubes. 17,165.
Godfrey, R F.: Rotary sleeve-valve engine. 17,120.
Gray, T. F.: Steam-superheaters. 17,128.
Haddon, W.: Wave transmission of power. 17,130.
Hattersley & Davidson: Pressure gauges. 17,045.
Henwood, G.: Solenoid motor. 17,111.
Hodges, W.: Controlling liquid fuel to internal-combustion engines. 17,291.
Hulme, F. A.: Utilisation of air currents for power purposes. 16,955.
James, H. V.: Control apparatus for electric motors. 17,011.
Jerrim, J. H.: Taps and valves. 17,300.
Jesper, A.: Internal-combustion engines. 16,975.
Johnston, H. B.: Crank gear for engines, &c. 17,234.
Jupe, E. J.: Steam superheaters. 17,128.
Kagan, M. L.: Pistons. 17,075.
King Petroleum Power Co.: Carburettors. 17,142.
Lane, J.: Solenoid motor. 17,111.
Leviseur, H. J.: Speed-indicators. 17,184.
Lines, J. P.: Self-driving motors. 17,293.
Mackenzie, J. W.: Carburettors. 17,142.
Matthewman, W.: Internal-combustion engines. 17,036.
Michelson, C.: Power-transmission apparatus. 17,134.
Moody, A. H.: Leverage utilised for driving purposes. 17,084
Moss, W. E.: Expansible packing-rings. 17,173.
Newton, C. E.: Carburettors. 17,069.
Newton, C. H.: Water-level gauges. 17,160.
O'Flanagan, F.: Internal-combustion engines. 16,975.
Pulsometer Engineering Co.: Turbine centrifugal pumps. 17,015.
Purchas, A. W.: Eduction pipe for air-lift pumps. 17,216.
Rimmer, G.: Coal-cutting machines. 17,284.
Semmler, C.: Internal-combustion engines. 17,029.
Southey, A. W.: Carburettors. 17,038.
Spencer, J.: Controlling supply of liquid fuel to internal-combustion engines. 17,291.
Spittle, J. S.: Lubricant pumps. 17,331.
Stratton, F. F.: Air-inlet valve for internal-combustion engines. 17,144.
Young, C.: Internal-combustion engines. 17,126.

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## COMPLETE SPECIFICATIONS ACCEPTED.

**1915.**

15,271—Jennings: Carburettors.
16,493—Chorlton & Livens: Valve mechanism of internal-combustion engines.
16,531—Gowans: Heating of feed-water.
16,595—D. Napier & Son Ltd., & Rowledge: Variable-speed gear.
16,596—D. Napier & Son Ltd., & Rowledge: Variable-speed gear.
16,686—Watson: Feeding of steam-generators.
16,755—Davis: Jet carburettors.
16,970—Smith, & Smith: Lubricators for piston-rods.
17,011—Newton & Howarth: Carburettors.
17,134—Carter, & Hans Renold Ltd.: Coil clutches.
17,405—Morison: Steam-condensing plant.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

**1916.**

1,170—Smith, V.: Steam-superheaters. **102,282.**
1,515—Craig, A.: Multicylinder internal-combustion engines. **102,286.**
1,757—Reiter & Gruenwald: Apparatus for cleaning the tubes of steam boilers. **102,287.**
2,414—Ball, W.: Winding-machines for yarn and the like. **102,293.**
3,020—Ritchie, E. G.: Belt-fastener. **102,295.**
3,970—Key, T. D.: Disc valves. **102,306.**
5,333—Yayes, H. J.: Brayshaw, S. N. and Brayshaw, E. R.: Furnaces. **102,318.**
6,500—Pressed Bearing Co.: Method of making lined bearings. **100,448.**
8,974—Yetton, J., and Brockett, W. E.: Wire staple belt-fasteners. **102,339.**
9,112—Westinghouse Machine Co.: Marine turbine installations. **100,797.**
9,574—Richards, C., and Richards, A.: Burner tubes of liquid fuel furnaces. **102,346.**
9,867—Babcock & Wilcox: Water-tube boilers. **102,352.**
9,878—Wilkinson, H. O.: Varying the stroke of a reciprocating engine. **102,353.**
10,064—Davies, H., Mason, P. F., and Wood, A.: Intercepting-valves. **102,355.**
12,005—Hartley, W. W., Sherwood, C. H., and Mackay, H. K.: Forcing belt-fasteners into the ends of driving-belts. **102,360.**

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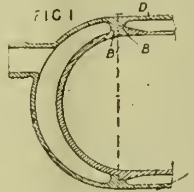
## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

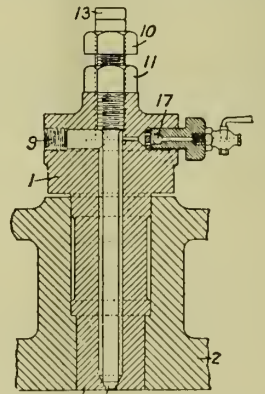
101,370.—E. C. S. CLENCH, Aster Engineering Co., Wembley, Middlesex.—A thin cast-iron cylinder A with an integral head is supported both laterally and longitudinally by a water jacket




D of aluminium alloy, which is shouldered at B1 to take the end thrust of the explosion and may be shrunk on to the cylinder at the part B as well as at C. Screwed tubes F unite the jacket and cylinder head and form valve pockets.

### STEAM-ENGINE AND LIKE INDICATORS.

101,373.—A. RYDER, "The Laurels," Hartford, Northwich, Cheshire.—A fitting for connecting an indicator to the cylinder of an internal-combustion or other fluid-pressure engine comprises a plug 1 which is screwed into the engine cylinder 2 or secured by bolts, and is formed with a seating for a valve 4, and with an opening 9 into which the indicator is screwed. In order to avoid a clearance space in communication with the

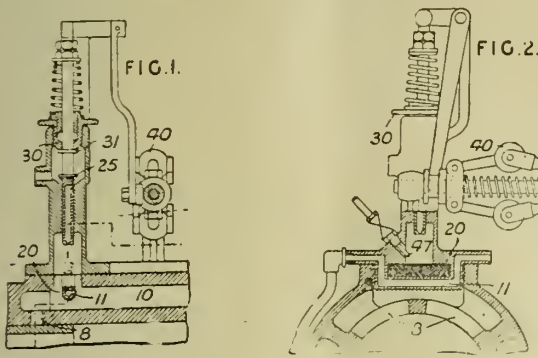



cylinder, the seating 4 of the valve is arranged, as shown, at the inner end of the plug. The valve spindle screws into the block 1 and is turned by means of a head 10 in order to open or close the valve. The spindle is locked by a nut 11, and the amount of valve opening is indicated and limited by a bracket 13. In order to clear the passages in the block 1, it is fitted with a non-return valve 17, through which scavenging air is drawn during the suction stroke of the engine.

### INTERNAL-COMBUSTION ENGINES.

101,451.—J. R. WALKER and A. E. WALKER, Oldbury Works, Tewkesbury, Gloucestershire. May 10th, 1916. No. 6681.—In the air-transfer passage 10 between the crank chamber and cylinder

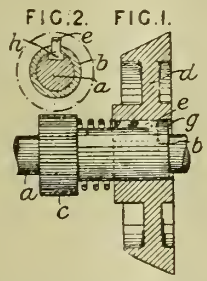
admission port 8 of a two-stroke cycle engine is situated, in a trough of gauze 20, an exhaust-heated vaporiser comprising a cranked pipe 11 for conveying some of the exhaust. Oil drips on to the pipe from a valve 25 with a lateral port in its hollow




stem. The valve is controlled by the governor 40, and can be screwed down on to its seat at starting by the stuffing box 30 engaging the roller 31 on its stem when petrol is supplied from a nozzle 47.

### SECURING ARTICLES ON SHAFTS.

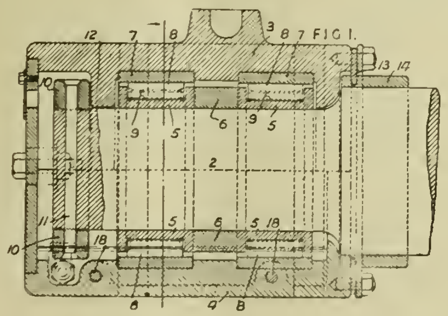
101,460.—W. SKAIFE, 671, Commercial Road, London.—June 8th, 1916. No. 8144. Means for slidably securing together a number of concentric parts, shown applied to a clutch part, a toothed wheel, and a shaft employed in the gear box of an automobile,




a key *e*, with or without an enlarged head *h*, passes through a slot in the sleeve *b* of the wheel *c* and engages a slot *g* in the clutch cone *d* and a slot or flat on the shaft *a*.

### BEARINGS.

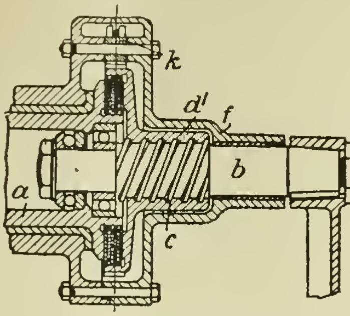
101,468.—J. HEPPELL, 134, Dilston Road, Newcastle-on-Tyne, and R. G. DOBSON, 32, Sidney Grove, Gateshead-on-Tyne.—July 29th, 1916. No. 10255.—A roller bearing for railway vehicle axle boxes comprises a pair of channelled races 5 shrunk or otherwise secured on the journal 2, a spacing ring 6, and a pair of outer races 7 mounted in a box which is divided transversely into two parts 3 4 connected together by bolts 18. The rollers 8 are spaced by smaller hollow rollers 9 formed with enlarged ends running




in contact with either the inner or the outer track. To retain the journal 2 in the box, a collar 10 screwed on to the end and locked by a pin or rivet 11 bears against a semi-annular rib 12 in the box. In a modification, the collar has a threaded stud screwing into the end of the journal and locked by a set-screw. A guard 13 engaging a groove in a collar 14 shrunk on the axle excludes dust and retains oil in the box. Rotation of the outer races is prevented by flat surfaces 16.

### CLUTCHES.

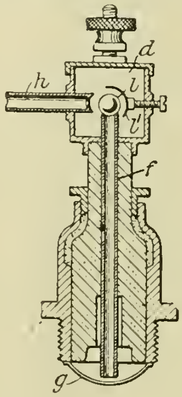
101,521.—F. H. ROYCE, Nightingale Road, Osmaston Road, B. I. DAY, 49, Harrington Street and ROLLS-ROYCE LTD., Nightingale Road, Osmaston Road, all in Derby.—May 31st, 1916. No. 7705.—In free-wheel clutches combined with means for preventing reverse movement of the driving parts and particularly applicable for use in engine turning gear, the driving shaft *b* carries a screw *c* engaging a screwed sleeve *d*1 forming the presser plate of a Weston plate clutch connecting the sleeve *d*1 and the



driven crankshaft *a*. A spring-pressed pivoted pawl *k* carried in the framing *f* prevents back-firing effects.

### SPARKING PLUGS

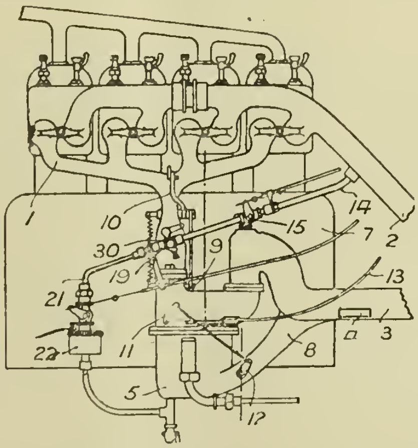
101,592.—A. E. LAMKIN, 86, Springfield Road, Brighton.—April 10th, 1916. No. 5240.—For automatically cleaning the terminals, a sparking plug is provided with a hollow central electrode *f*, the outer end of which projects into an air-tight box *d*. A tube *h* communicating with the cylinder head also opens into the box *d*,



its end being closed by a ball *l* on the suction stroke of the piston, the ball being thrown back against its adjustable seating *l*1 during the compression stroke, so that gas may circulate through the interior of the plug. The earthed electrode consists of a metal filament *g*.

### INTERNAL-COMBUSTION ENGINES.

101,596.—F. A. WILKINSON, The Meadows, Hatfield, Hertfordshire.—April 25th, 1916. Nos. 5921 and 7779.—In engines using paraffin or other heavy fuels, hot exhaust gases are added to the combustible mixture before its admission to the cylinder. As shown in Fig. 1, air, which may be heated, is drawn through a pipe 3, having a cold air-inlet orifice at 4, and enters the carburetter

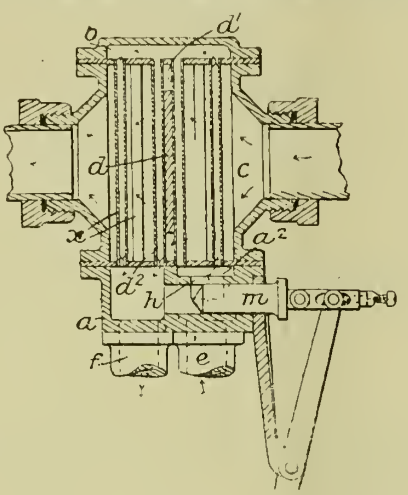


through branch pipes 7 8 containing controlling valves 11 12 actuated simultaneously by a wire 13. A throttle valve in the outlet pipe of the carburetter is controlled by an arm 9 connected to a lever 10. Exhaust gases from the outlet pipe 2 of the engine are fed to the carburetter, above the throttle valve in the outlet pipe 1, through a pipe 14 containing a controlling

valve 15. Located at the carburetter end of the pipe 14 and opening into the outlet pipe 1 is a cross piece 19, through which air may be drawn past a suction-actuated valve or a mechanically-operated valve 30 to regulate the temperature and composition of the mixture. The cross piece communicates also through a pipe 21 with a supplementary fuel chamber 22 or, alternatively, with the float chamber 5. Fuel, at starting or during normal working, may thus be drawn direct into the pipe 1 without passing through the carburetter. The fuel in the float chamber, or the chamber 22, may be heated by an electric coil or other means, the current to the heater being cut off automatically when the engine is running normally. The carburetter may have an exhaust-heated or hot-water jacket; the air admitted through the cross piece may be heated, and the fuel before it reaches the carburetter may be warmed in bulk or by leading it through or around the exhaust pipe. At starting, the cross piece may be warmed by a blow-lamp. If a light fuel is used at starting, it may be supplied from a separate carburetter or from the float chamber 5. Water may be admitted to the pipe 14, and gauze screens may be located in the outlet pipe 1 above the cross piece 19.

### INTERNAL-COMBUSTION ENGINES.

101,597.—E. W. JOHNSON, 6, Lifford Avenue, Ballinacurra, Limerick.—May 8th, 1916. Nos. 6577 and 8578.—In a vaporiser for use with spray carburetters, the temperature of the mixture passing to the engine is varied by bye-passing some of the cold vapour and allowing it to mix with the heated vapour without having passed through the vaporiser. The vaporiser comprises end chambers $a$, $b$ connected by tubes $x$, which pass through a chamber $c$ to which exhaust gases are admitted. The tubes $x$ are closely arranged to form baffles, and a baffle plate $d$ with apertures $d1$ $d2$ is also provided. Normally, mixture enters at $e$




and passes through the tubes $x$ to the chamber $b$, whence it again traverses the tubes to the outlet $f$. A portion of the cold mixture may, however, be passed direct from the chamber $a2$ to the outlet $f$ through a bye-pass $h$ controlled by a valve $m$ connected through a lost-motion device, to the throttle valve. The bye-pass opening is shown of rectangular form, but may be tapered. A modified construction is shown wherein the mixture traverses the tubes only once. It may traverse them more than twice.

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Controlled Establishments and Secrecy.—We have received the following official notification for publication: The Minister of Munitions appeals to the owners of controlled establishments, to all persons responsible for the management of such establishments, and to the public generally to guard against communicating to neutral countries information concerning controlled establishments, the effects of control on the conduct of their business, and the character and quality of munitions work in hand. Such information is sometimes conveyed (probably by inadvertence) in replies to inquiries as to whether particular establishments are able to undertake particular classes of work, and also in advertisements in newspapers which circulate abroad. The public are warned that no communications of any kind can be transmitted abroad (1) if they give any indication that a firm is controlled or is engaged in munitions work or (2) if they contain information with respect to the manufacture, output, or supply of munitions, or with respect to the place where such work is carried on.

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# INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

Vol. V.] JANUARY 8th, 1917. [No. 126.

## The Industrial Engineer.

*ENTIRELY DEVOTED TO POWER ENGINEERING.*

Published twice monthly, on the 8th and 22nd days, respectively.

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CONTENTS.



# EDITORIAL.

## LABOUR AND LABOUR EXCHANGES.

If anyone had any doubt as to the selection of the right man to fill the post of Minister of Labour, that doubt would surely be expelled by reading the report of the speech of Mr. John Hodge, M.P., during last week-end. Those who knew Mr. Hodge's calibre were not disappointed when he was selected to fill the position of Labour Minister. He always had the courage of his convictions and was fearless, whilst being courteous, in expressing them. His speech fully expressed what he sincerely felt, and strong as it was in reference to Labour Exchanges, we have no doubt that privately his language would be stronger and more picturesque still. However strong his views are, they are more than justified by the crass stupidity with which Labour Exchanges in general have been conducted. They were originally capable of a vast amount of good. They began with a good principle as a base, but, like many other public institutions, they have got into the wrong hands; they are mainly conducted by men who are totally out of sympathy with the objects for which they were established, men full to the brim with the spirit of bureaucracy, and hence they have become largely akin to poor law institutions in the method and manner of their operations. This is no sectional expression of opinion, for, as Mr. Hodge rightly said, neither employers nor trade unionists liked them, and they would only become really useful when they were given heart, lungs, brain, and soul—life and inspiration. They will never get this so long as the bureaucratic methods referred to obtain, but that such methods will be superseded we have not the slightest doubt, whilst the Ministry of Labour is under the strong, compelling influence of Mr. Hodge's forceful personality. We wish him the best of luck in breathing into the dry bones of this moribund institution the stimulating breath of common sympathy, common sense, and common honesty, coupled with expert knowledge both of the conditions of labour, the status of the labourer, and the legitimate requirements of the employers fortified by a knowledge of their varied requirements and general conditions of trade. There is no necessity for anything antagonistic either to the interests of employers or employees to enter into the efficient working of Labour Exchanges. Mr. Hodge ought to have, and we sincerely hope he will have, the hearty co-operation of all sections of industry in his manly and earnest endeavour to put some life into this public department. If this is forthcoming we have no doubt that Labour Exchanges will fulfil the duties for which they were originally designed, and prove of inestimable service to the industrial community.

### Welfare Schemes.

The Labour Minister was equally happy in dealing with this subject, and there was strong common sense in the expression of his belief that employers had begun to realise that welfare was a valuable asset to the productivity of the worker, and that it paid to treat men, women, and children, as well as cattle, kindly. War has had its influence in this direction, and we hope and believe that the co-operation and comradeship evolved in this devastating war will extend and multiply, so that welfare schemes may be established on a sound and lasting basis.

Mr. Hodge dealt with many other industrial problems which need attention and will force themselves into prominence from now onwards. We have not space, on the present occasion, to deal with and give them a helping hand, but we may conclude by saying that in every one of them the new Labour Minister struck a note which ought to have a hearty response both from the ranks of capital and labour.

# A METHOD OF DETERMINING THE DENSITY OF FLUE GASES.*

By Jas. Alex. Smith, Past President.

Engineers, whether power, metallurgical or manufacturing, can always ascertain the density of the gases within their province, either by chemical analysis or precision weighing. But it is not always essential to know the chemical composition; or the composition may be deducible with sufficient accuracy if the density is known. Then methods of a simpler or more direct character have a use, particularly when it is desired to study cause and effect concurrently, and without any appreciable intervening interval during which the cause might vary.

The purpose of this paper is to describe a mode of determining gas density by gauge reading. So far as the writer is aware, the method is new.

## General Principles.

The basic theorem is that the densities of gases and their pressures per unit area of base are directly proportional when the gas columns are of equal height. Hence, if a column of air in a vertical tube of known height is displaced by a given gas, the barometric and thermometric conditions remaining constant, the densities are in the simple ratio

$$D = \frac{P \pm P'}{P} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

when

D = Density of the given gas referred to air taken as unity,

P = Known air pressure due to column height, and

P' = Difference ($\pm$) of pressure due to gaseous displacement.

## Pressure Measurement.

Assume that an accuracy within 1 per cent of the total air pressure due to the vertical or column height is required; in other words, that a pressure due to the air in a column the one-hundredth of the height of the column in the given case must be evaluated. This order of minuteness of magnitude at once contra-indicates mechanism subject to friction, and indicates the use of "frictionless" liquid gauges.

Postulating that, without the introduction of undesirable complications, 0·02 in. is the smallest significant difference of level of such a gauge, then the relation of that minimum gauge space to the minimum correlated gas-tube height ($h$) is given by the equation

$$h = \cdot 02 \text{ in.} \times 100\,x \quad . \quad . \quad . \quad . \quad . \quad (2)$$

when $x$ is the specific gravity of the gauge-liquid referred to *air* as unity. Therefore water, which is about 772 times heavier than air, if used in a simple syphon gauge, and under the conditions postulated, requires a complementary gas-tube not less than 0·02 in. × 100 × 772 = 1,544 in. — about 130 ft. in height. Conversely, if the height ($h$) in inches be given, then the maximum specific gravity of the possible gauge liquid (air, as before, being taken as unity) is determined by the formula

$$x = \frac{h}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

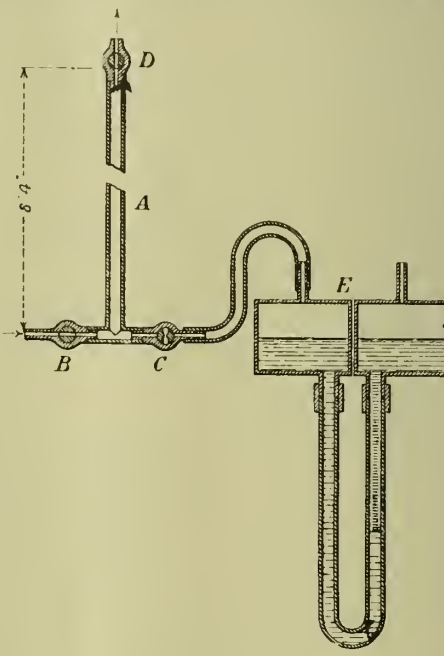
Any convenient value may be assigned to $h$. Let, then, the vertical height of the gas column be 100 in. Then $x$ = specific gravity 50. That is, for such a tube height, a liquid is indicated not more than 50 times heavier than air, or, $\frac{772}{50} = 15{\cdot}44$ times lighter than water.

No such light liquid is known; but its equivalent may be attained if two immiscible liquids are caused to partially equilibrate each other in such a manner that the *difference* (which may be made as small as desired) of the specific gravities becomes the measure of the equivalent specific gravity of the liquid system as a whole.

A gauge on the differential principle, capable of readily dealing with gas pressures of the small magnitude in question, has already been described by the author in the "Proceedings" for November, 1909, vol. X., page 155, under the title, "A Simple, Sensitive, Two-Liquid Differential Gauge for Measuring Small Pressures."†

## Gas Tube.

The gas tube is very simple. In the example illustrated it consists of a piece of ⅛ in. wrought-iron gas-barrel, A,




A—Gas tube. B—Inlet gas cock. C—Gauge cock. D—Outlet gas cock. E—Differential gauge.

**Note.**—The barometric equalising vent (at D) is not shown. It consists of a piece of clockmaker's "bushing wire," 1 in. long and $\frac{1}{50}$ in. bore.

100 in. in height. At the bottom two stopcocks, B, C, permit alternative connection to a gas-source or to a gauge, E. To check diffusion, the passage through the latter cock should be reduced to a pin-hole. At the top a third cock, D, opening into the air, permits the tube to be gas-flushed and filled, and when the main passage is closed continues the connection by a minute by-pass large enough to preclude any possible barometric difference of pressure between the gas inside and the air outside the tube, yet so small that diffusion is negligibly slow. The surface of the liquid in the gauge cistern and the bottom of the gas tube must be approximately at the same level.

## Calibration.

If the gauge constants are unknown, a simple, comprehensive calibration covering all the factors can be effected

* Paper read before the Victorian Institute of Engineers, July 6th, 1916.

† Also reprinted in "Engineering," vol. xc., page 144.

thus: All parts being filled with air, adjust the gauge to zero. Then displace the air in the tube with any easily generated or procured gas of known density, for instance $CO_2$, the specific gravity of which is 1·524. Then the pressure upon unit of base of 100 in. vertical of $CO_2$ is equal to the pressure of 100 × 1·524 = 152·4 in. of air. Therefore the consequent liquid displacement due to the displacement of the air by gas is equivalent to that which would be caused by an air pressure of 152·4 − 100·0 = 52·4 in. The scale can be graduated or interpreted accordingly.

## Corrections.

When relativity only is required, corrections may be dispensed with. The case of the immediate effect of draught volume variation upon chimney-gas density is an example.

But if absolute readings are required, and if barometric and thermometric conditions differ from those which may have been assigned in respect to P (formula 1), and upon which the value of the gauge divisions is computed, then a corrected value $P^2$ must be substituted for observed $P^1$ in formula (1); then

$$P^2 = \frac{(461 + t)\,29{\cdot}92 \times P^1}{461 \times b} = \frac{(461 + t) \times P^1}{15{\cdot}41 \times b} \qquad (4)$$

when

$t$ = Observed temperature on Fahrenheit scale,

$b$ = Observed barometric pressure in inches,

$P^1$ = Observed pressure due to gas displacement, and

$P^2$ = Corrected value of observed displacement pressure.

Strictly, a further correction should be made to compensate for the variation in the gas system volume, due to the movement of the liquid in the gauge. Usually, however, this amount is so small that it may be neglected in practice.

## Scales.

The actual graduations may be in any convenient term, *i.e.*, density or specific gravity, percentages, or direct evaluations of the major object of the test.

## Variants.

(1) The mode is equally applicable in the case of density change due to chemical reaction other than combustion.

(2) In the case of inconveniently high tubes, all adjustments may be brought within operative reach by constructing the tube as an inverted ∩, providing that the minute equalising vent must then be placed at the vertex, and must remain permanently open.

(3) A gas tube within a chimney and extending to its full height affords a means of ascertaining the density of the chimney gases at the *mean* temperature within the whole stack. From this may be deduced the potential ascensional power of the gases, a result not given by the ordinary draught gauges, which show the utilised value only.

(4) Obviously portability can be attained by constructing the tube in screwed sections.

(5) Photographic continuous records can be attained by the use of any of the well-known devices. This implies a constant passage of gas; therefore precautions must be taken against the vitiation of the results by the introduction of extraneous pressure head, either by periodically cutting off the gas supply or by making the inlet very small in comparison with a relatively large outlet permanently open. Necessarily there will be a lag in the records in respect to time.

# NATIONAL ELECTRIC POWER SUPPLY.

*(Continued from page 104.)*

The deputation considered that powers should be given to a Joint Committee or Joint Board, with a view to co-ordinating the electrical supplies in the various districts on the following lines:—

(*a*) To raise capital from time to time fo rthe provision of linking-up mains, transformers, and such other works as may be required for interconnecting purposes, and to allocate all expenditure on the joint scheme on an equitable basis between the undertakings participating in the joint scheme.

(*b*) To adjust the running hours of the existing generating stations in such a way that the maximum fuel saving might be effected. This would entail the shutting down of certain stations during the night or week-ends, or at times of light load, the supply being furnished by the stations possessing the more economical plant.

(*c*) To lay down general rules for determining the charges to be made for:—

1. Reciprocal supplies.
2. Standby supplies.
3. Bulk supplies.

(*d*) To act in an advisory capacity in regard to future extensions of plant—that is to say, to recommend where such extensions could be carried out to the greatest advantage.

(*e*) To apoint from time to time such officials as may be necessary to act in an advisory capacity to the Board, and to carry out the instructions of the Board, under powers which may hereafter be conferred by the Government.

The representatives of the Government Departments recognised that some measure of control should be vested in such a Joint Committee if the best results were to be obtained from the scheme.

As a result of its investigation the Committee is satisfied that very substantial economies can be effected by the interconnection of the various electrical undertakings comprised in Groups A, B, C, and D, as indicated above.

(*a*) In order to bring the scheme before the local authorities and others concerned, the Committee recommends that a conference should be held at an early date of all the statutory supply authorities included in Groups A, B, C, and D. Such conference to be presided over by a Government official.

(*b*) That, subject to general approval being given to the scheme by the authorities concerned, an application should be made to the Board of Trade to set up a Joint Committee or Board, under Section 8 of the Electric Lighting Act, 1909, with general powers on the lines recommended in the report, and with the addition of further powers, if required, to enable agreements to be entered into with the power companies, whose inclusion in the scheme is regarded as essential.

(*c*) That pending the appointment of such a Joint Committee or Board, undertakings favourably situated may enter into voluntary arrangements for joint working. Provided that where existing works or works to be laid down for the purpose of inter-connecting are suitable and sufficient to form part of the whole co-ordinated scheme at a later date the capital expenditure on such works, or the annual charges on same, shall be recoverable from the Joint Committee or Board

(*d*) In order to ensure that any local scheme for interconnecting shall be carried out in such a way as to conform with the requirements of the scheme as a whole, the Committee recommends that if the proposals contained in this

report are adopted, the local authorities interested should temporarily appoint a Joint Committee, to which all proposals for the provision of mains or other interconnecting works shall be submitted for approval or otherwise before such works are commenced.

The report is signed on behalf of the Committee by Mr. S. L. Pearce (chairman) and Mr. J. A. Robertson (hon. secretary).

The estimated expenditure is as follows:—

| | |
|---|---|
| (1) Estimate of cost to interconnect existing systems in Group A...... | £58,839 |
| (2) Estimate of cost to interconnect existing systems in Group B...... | 31,375 |
| (3) Estimate of cost to interconnect existing systems in Group C...... | 23,900 |
| (4) Estimate of cost to interconnect Group A with Group B and Group C .............................. | 83,783 |
| (5) Estimate of cost to interconnect existing systems in Group D...... | 83,500 |
| Total ....... .................. | £281,397 |

The new mains required average 22,000 yards per group, ranging from 8,800 to 48,400 yards; with 20,680 yards for interconnecting the groups, the aggregate length is 109,550 yards, or about 62¼ miles. The total capital expenditure and other details regarding the groups are given below—

| Group. | Capital outlay. | Generating plant capacity, KW. | Boiler plant capacity, KW. | Coal consumed per unit gen., lb. |
|---|---|---|---|---|
| A ... | £4,383,748 | 131,968 | 123,680 | 2·95 |
| B ... | 2,112,015 | 65,636 | 58,900 | 3·60 |
| C ... | 895,728 | 33,085 | 23,530 | 3·39 |
| D ... | 954,097 | 30,229 | 22,600 | 4·0 |
| Total... | £8,345,588 | 260,918 | 228,710 | — |

The total maximum demand of the 26 undertakings scheduled last winter was 138,429 kw.; next winter it is expected to be 160,862 kw. The total units generated in the last completed year amounted to over 421 millions, and the average coal consumption of all the stations was 3·24 lbs. per unit generated.

*(Concluded.)*

## HEAVY-OIL ENGINES.

By S. B. Daugherty.

*(Continued from page 106.)*

### Vertical v. Horizontal Diesel Engines.

One of the outstanding features of Diesel-engine manufacture in the United States is that, in general, those manufacturers who have done their own designing have brought out horizontal engines, while those who are building vertical engines have purchased the designs abroad.

The advantages of the horizontal engine, as enumerated by a concern with an established reputation as builders of vertical engines, are: Lower price; easy survey and convenient attendance; better distribution of stresses on the crankshaft and main bearings; better lubrication of bearings; better lubrication of piston; easier cleaning and repair work, especially to pistons, which can be taken out without removing the cylinder head and the valve gear; reduced height of engine-room, as all pipes are laid in trenches under the floor and do not obstruct the room.

In a comparison of vertical and horizontal Diesel engines, the detail most discussed is the piston. Vertical builders call attention to the weight of the piston, and the side pressure thereby produced on the cylinder bore, in the case of the horizontal engine. The fact that the first Diesel engines were built vertical, and that excessive height was undesirable, probably led to the use of trunk pistons. For the same reason a connecting-rod of a length but slightly more than five cranks, has been utilised in vertical engines. An analysis of the forces prevailing throughout the cycle of operations shows that the side pressure on the cylinder walls, due to the angularity of the connecting rod, is far greater than the pressure due to the weight of a piston, even though the piston lies horizontally. Any increase in connecting-rod length means a proportional decrease in the side thrust. Ordinarily an increase in the length of the connecting rod of one crank length decreases the side thrust an amount equal to the weight of a piston and wrist pin, or, in other words, a vertical trunk-piston engine with a connecting rod five cranks long is subjected to about the same side pressure

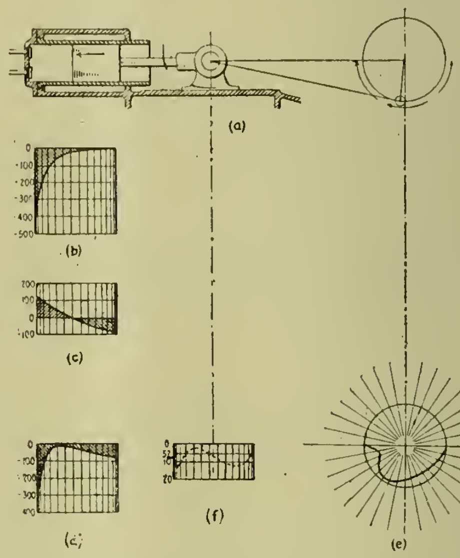



Fig. 4.—Piston Effort Diagrams for Horizontal Oil Engine, Compression Stroke.

on the cylinder wall as a horizontal trunk-piston engine with a connecting rod six cranks long.

The magnitude of the forces involved in the engine is not generally realised. Weight is obvious, but loads due to fluid pressure inside of cylinders and the reactions resulting therefrom are not so readily appreciated. For example, with a connecting rod five cranks long, and the engine crank 45 deg. from dead centre on the working stroke, the side thrust on the piston, not considering the modifying effect of inertia of the reciprocating parts, is about 41 lbs. per square inch of piston area. For a 19 in. diameter piston, this is 284 × 41 = 11,640 lbs. The weight of a 19 in. piston with wrist pin and one-half of the connecting rod is approximately 1,600 lbs. The side thrust due to angularity of the connecting rod for this condition is about 7·3 times the weight of piston. In actual running, the force transmitted to the crank pin through the connecting rod is reduced by inertia effects, so that the side thrust due to angularity is from five to six times the piston weight instead of 7·3 times.

In order to present this feature more clearly, diagrams are given showing the pressures acting on the piston dur-

ing the compression and working strokes; the inertia; the combined inertia and pressures, which is the measure of the effort transmitted to the crank pin; the turning effort on the crank pin, and the resulting thrusts due to the angularity of the connecting rod. The figures on the diagrams are in pounds per square inch of piston area. In these piston-effort diagrams, the forces which tend to drive the crank in clockwise direction are shown above the horizontal base line, and those forces that would tend to drive the crank in the reverse direction are shown below the base line.

Beginning with the compression stroke, Fig. 4*a*, note that the crank is driving the piston against a constantly increasing pressure, which reaches 500 lbs. per square inch at the end of the compression stroke, Fig. 4*b*. At the beginning of the compression stroke, when the inertia of the reciprocating weights must be overcome, the pressure in the cylinder is low. At the end of the compression stroke the inertia effect is tending to revolve the crank in clockwise direction, as shown in Fig. 4*c*. Note, in Fig 4*d*, how closely

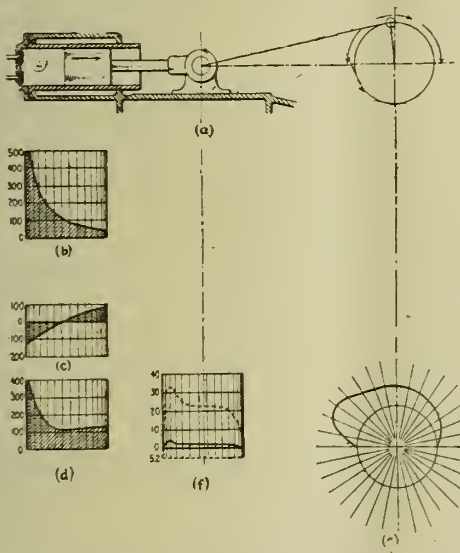



Fig. 5.—Piston Effort Diagrams for Horizontal Oil Engine, Working Stroke.

(a) Frame diagram; (b) compression diagram; (c) inertia diagram; (d) combined compression and inertia; (e) crank effort; (f) reaction on cross head guide.

the line approaches the base. An increase in the weight of the reciprocating parts or an increase in the rotative speed of the engine would cause the line to cross the base line, or, in other words, would result in the piston actually pulling the crank during a short portion of the compression stroke; such a condition tends to cause a knock. From this piston-effort curve the negative turning effort on the crank is obtained, Fig. 4*e*, and the reaction on the cross head due to the angularity of the connecting rod, Fig. 4*f*. On the compression stroke, the tendency is to lift the crosshead throughout the stroke. The upward thrust is maximum near the end of the compression stroke, and equals 14·5 lbs. per square inch of piston area. The weight is about 5·2 lbs. per square inch, so that the net upward thrust is 9·3 lbs. per square inch of piston area, or 10,700 lbs. For a 19 in. diameter piston, upward thrust is resisted by adjustable gibs bearing on the sides of the crosshead shoe, and no trouble is experienced in making these adjustments so that the engine runs quietly.

At the end of the compression stroke, fuel is injected and the working stroke follows, Fig. 5*a*. The pressures in the cylinder throughout the stroke are indicated in Fig. 5*b*. The inertia diagram for this stroke is shown in Fig. 5*c*. Note particularly, in Figs. 4*d* and 5*d*, the benefical effect of inertia in reducing the high pressures at the end of the compression stroke and the beginning of the working stroke, and in supplementing the low pressures in the cylinder at the end of the working stroke so that the effort is more evenly distributed. During this stroke the thrust due to the angularity of the connecting rod is all downward, Fig. 5*f*, and reaches a maximum of 32·6 lbs. per square inch of piston area. Adding the weight to this, the maximum downward pressure is 37·8 lbs. per square inch of piston area, or 10,700 lbs. For a 19 in. diameter piston, note particularly that if the cylinder were vertical there would still be a maximum side thrust of 9,250 lbs.

From the foregoing it will be very apparent that it makes but little difference whether an engine is built vertical or horizontal in so far as side pressures are concerned. In the case above analysed, weight adds but 16 per cent if the maximum pressure is considered. The advantage of the horizontal engine in general, and the crosshead type in particular, is in its superior accessibility. In the case of a vertical trunk-piston engine it is necessary to practically dismantle the engine in order to get at the piston, piston rings, or wrist-pin bearings. In most cases the valve gear and the cylinder heads must be removed, the connecting rod must be disconnected at the crank pin, and the piston and piston rod then lifted out through the cylinder.

Compare this procedure with that necessary in the horizontal engine: The sheet-steel crank splasher is removed; then the connecting rod is disconnected, at the crank pin in the case of a trunk-piston type, or more simply at the wrist pin if the engine has a crosshead, and the piston is then removed from the open end of the cylinder. The actual time required to remove a piston and crosshead of a 19 in. by 33 in. engine was 20 minutes. The piston was wiped clean and replaced in 30 minutes, making the total shut-down 50 minutes, as compared with about one day of 10 hours to accomplish the same thing in the case of a vertical engine.

## Type of Diesel Engine and Lubrication.

The matter of cylinder lubrication is another feature of superiority in horizontal engines. In the vertical type it is absolutely essential, in order to secure a distribution of the lubricant around the cylinder bore, to supply the oil through a number of feeds, as many as four per cylinder on the smallest sizes and more on larger diameters. A horizontal cylinder, on the other hand, even of the largest size that is practicable to build, can be effectively lubricated over its whole surface from a single feed on the upper side. Gravity helps to distribute the oil.

In any internal-combustion engine some of the lubricating oil is carbonised. In a vertical engine this carbon tends to work down past the piston, fouling the rings and dropping into the crank pit, where it becomes mixed with the bearing oil. In the horizontal type, much of this carbon is pushed into the counterbore, whence it can be removed through a blow-off valve in the bottom of the cylinder. Such portion as works by the piston can be caught in the frame and prevented from mixing with the bearing lubricating oil. Even the main bearings in a horizontal engine are more effectually lubricated.

During the working stroke, when the pressures are highest, the main shaft is partly lifted from the bottom shell, allowing the lubricant to fill the space. Then on the two idle strokes, the exhaust and inlet, inertia effects tend to bring the shaft first against one side of the bearing, then against the other, thus effecting a very thorough distribution of the oil.

*(To be continued.)*

## THE WERKSPOOR-DIESEL ENGINE.

By F. R. Parsons.

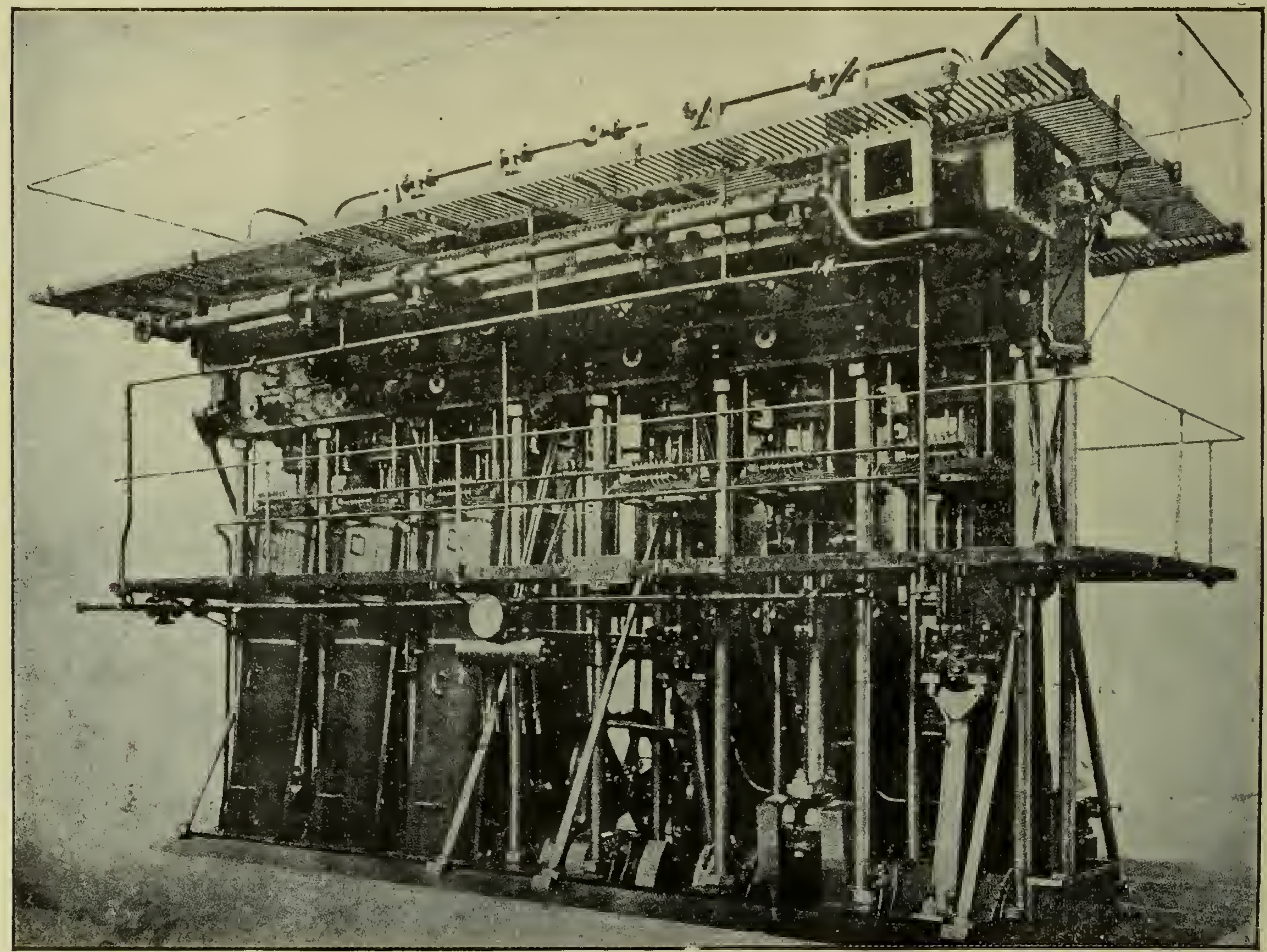
Although comparatively unknown in this country, the Werkspoor-Diesel engine would appear to be coming rapidly into favour, both for land and marine purposes, in America. For the following technical details and illustrations of this type of oil engine the present writer is indebted to Mr. T. Orchard Lisle, sole U.S. representative and, incidentally, the writer's friend and one-time colleague.

The engine illustrated by Fig. 1 is the 1,500 indicated horse-power model, which develops 1,100 B.H.P. at about 125 revolutions per minute from six single-acting cylinders, each 22 in. bore by 39¾ in. stroke. Its length is about 27 ft. by 8½ ft. width, and 16 ft. 9 in. high above the crankshaft. It will at once be noted that it is an engine in which accessibility has almost been brought to an unusual condition by reason of it being quite of the open crank-pit type, with the cylinders mounted on steel columns; while strength and rigidity are added by steel cross-stays, with the cross-head guides on cast-iron frames at the back of the engine.

The six working cylinders are divided into two sets of three, with the camshaft driving gear and all the control levers between.

A feature quite unusual with British-make engines of the multiple-cylinder vertical make is to be found in the arrangement of the camshaft operating gear. At the back of the engine, just over the bedplate, is a small lay crankshaft operated by two-to-one reduction spur gearing off the main crankshaft. On this lay shaft there are four crank-throws, and the motion is directly transmitted to similar crank-throws on the camshaft by means of four hollow, girder-shaped rods; thus the camshaft is given an even and continuous rotary motion, each throw being set at right angles to the others. A further unusual feature of this detail is that these rods are split-steel tubes, held apart by cross-stays, which, it is claimed, eliminate all vibration.

In engines of this type designed for marine purposes, there are two camshafts, one for ahead running and one



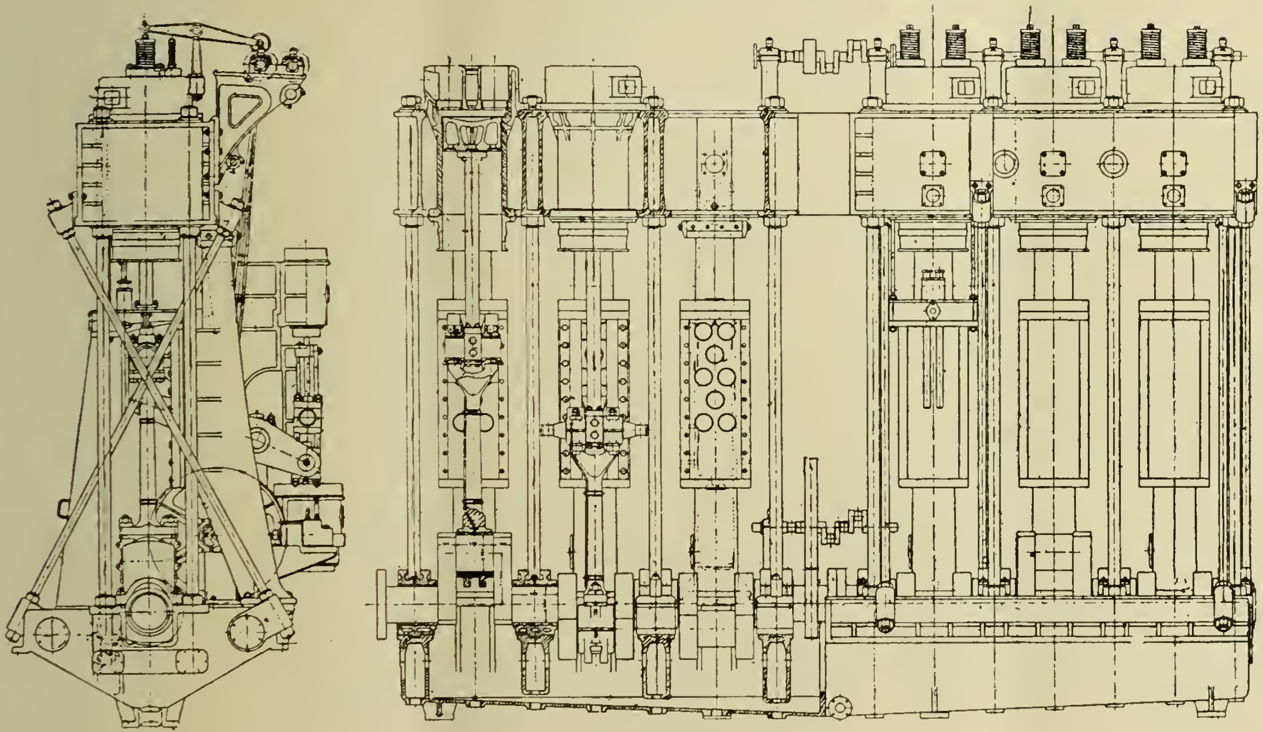
The Werkspoor-Diesel Engine.—Fig 1

for astern movement, these shafts being mounted on sliding brackets. When manœuvring, these brackets, by sliding to and fro as desired, bring a different set of cams under the rollers of the valve rockers, thus reversing is but a matter of very short time. In fact, it is claimed that the time occupied to reverse from full ahead to full astern is from 5 to 10 seconds. To start the engine up from cold occupies but from 3 to 5 seconds. The arrangement of levers, camshaft, etc., referred to, also a section through a working cylinder, is shown in Fig. 2.

Among other unique features in connection with the Werkspoor engine is the fuel-supply arrangements. Most Diesel engines have a separate fuel pump to each cylinder, which are regulated by opening and closing the individual suction valves, but this method is considered by the Werkspoor firm not sufficiently reliable, and water-cooled, this being effected by means of clearance pipes and a pressure jet. Both these are exclusive and patented features.

Except for the cylinders, sight-drip-feed lubrication is employed throughout, all superfluous oil caught from the splash-guards being caught in a centre sump of the crank-pit and passed through a filter and cooler before being re-used. The three-stage air compressor is driven off the fifth cylinder by means of a link and beam lever on the crosshead at the back of the engine, thus making the Werkspoor design completely self-contained.

Regarding the nature and quantity of fuel used, it would appear that residual oils are used in the Werkspoor engine, although extremely heavy oils can be consumed, but this, of course, is only recommended when lighter grades of oil are not available. As an instance of this, it may be of interest to note that at the Werkspoor



The Werkspoor-Diesel Engine.—Fig. 2.

requiring too delicate an adjustment to supply exactly the same quantity of fuel to each cylinder. Therefore they provide a single pump, which supplies two distributing boxes, each box having feeds to three cylinders, while every feed has its own adjuster. In order that the engineer in charge shall have some idea as to whether any one cylinder is receiving more or less fuel than the others, a thermometer is fitted to the exhaust branch of each cylinder; thus differences of temperature denote irregular fuel supply. As a stand-by, an extra pump, with a simple change-over device, is fitted. By an arrangement of capacity of reservoir, the fuel supply is designed to permit the engine to run for a period of about 15 minutes in the event of the fuel pump failing temporarily.

Another important feature is the design of the cylinder liner. As will be seen from the sectional illustration, this extends below the jacket in a detachable form, thus facilitating the easy removal of any piston without dismantling any portion of the engine. The pistons are works a trial engine was run without trouble of any kind for a considerable period on Mexican crude oil of the following analysis:—

| | |
|---|---|
| Specific Gravity at 15 deg. Cen. ... | ·862 |
| Flash Point (closed test) ... ... | 140 deg. Fah. |
| Calorific Value ... ... ... ... | 17,430 B.T.U. |

An average consumption of several Werkspoor engines, calculated on a medium quality oil, has been found to be about 0·30 lb. per indicated horse-power hour.

Hydro-electric Power in Spain.—It appears that there are now 50 hydro-electric plants with an available horse power of over one million working in Spain. It is estimated, however, that it is practicable to produce from water power quite 6,000,000 H.P., of which over one million could be derived from the River Ebro and its effluents. Capital for such developments has in the past been provided mainly by France and Great Britain. It is to be hoped that the interest of these countries in the matter will not be lost owing to the vast expenditure of capital during the war.

# TRIALS ON A DIESEL ENGINE, AND APPLICATION OF ENERGY-DIAGRAM TO OBTAIN HEAT BALANCE.

By the late Lieut. F. Trevor Wilkins (Northumberland Fusiliers), M.Sc., of the University of Birmingham, Graduate.

(*Continued from page 113*).

## Measurement of Injection Air.

In the engine as originally constructed, the first stage injection air-compression was carried out in the engine cylinder, an overflow valve in the cylinder head tapping off a small quantity of air at each compression stroke. The air then passed through an intercooler to a high-pressure

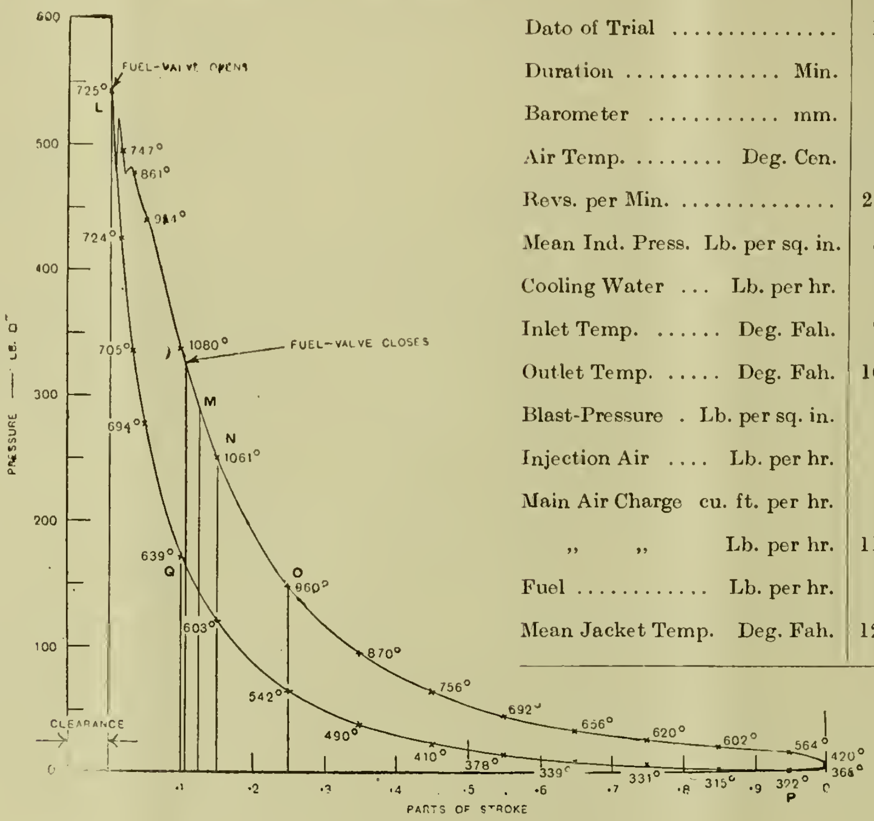



Fig. 5.—Half Load Mean Indicator Diagram.

M.I.P. = 55·3 lb. square inch. Temperatures in degrees Centigrade absolute.

compressor cylinder, in which the pressure is finally raised from 160 lbs. per square inch to the pressure of the bottles. For the trials this overflow system was cut out, air being supplied to the compressor cylinder from a storage reservoir of known capacity, and pumped up to nearly the same pressure before each trial.

## Measurement of Main Air Charge.

The air supply was measured by a Parkinson wet meter of 1,200 cubic feet per hour capacity, or 10 cubic feet per revolution. This meter was connected to the inlet pipe of the engine by an 5 ft. length of 2 in. internal diameter iron pipe; at the meter end of this was placed a cylindrical iron tank 4 ft. 6 in. by 2 ft. 6 in. in diameter. A throttling plate fitted between the tank and meter was adjusted until the pressure difference across the meter as shown by the water gauge was practically steady. This arrangement quite effectively damped out the intermittent demand for air, the meter reading very steadily with a pressure difference across it of between ⅜ in. and 7/16 in.

The meter was set in the standardising position, and during the trials the water-level was maintained by means of a water drip. Light spring cards were taken off the engine before and after adding the meter, and no appreciable difference was noted. No air can pass through this type of meter without its measurement being recorded, unless the pressure difference is sufficiently great to depress the water-level 1½ in. and to by-pass under the partitions of the air compartments. The occurrence of this is indicated by the noise produced.

TABLE 1.
Test Results.

| | Units. | Half Load. | Three-quarters Load. | Full Load. |
|---|---|---|---|---|
| Date of Trial | | 15.6.13 | 17.6.13 | 25.6.13 |
| Duration | Min. | 60 | 60 | 60 |
| Barometer | mm. | 753 | 748·5 | 755 |
| Air Temp. | Deg. Cen. | 21·7 | 21·4 | 24·5 |
| Revs. per Min. | | 277·17 | 275·07 | 271·97 |
| Mean Ind. Press. | Lb. per sq. in. | 55·27 | 70·35 | 86·14 |
| Cooling Water | Lb. per hr. | 139 | 157 | 225·5 |
| Inlet Temp. | Deg. Fah. | 75·4 | 75 | 81 |
| Outlet Temp. | Deg. Fah. | 165·6 | 167·9 | 163·85 |
| Blast-Pressure | Lb. per sq. in. | 694 | 694 | 694 |
| Injection Air | Lb. per hr. | 6·86 | 6·5 | 5·13 |
| Main Air Charge | cu. ft. per hr. | 1555 | 1538 | 1526 |
| ,, ,, | Lb. per hr. | 115·42 | 113·72 | 112·275 |
| Fuel | Lb. per hr. | 2·094 | 2·688 | 3·389 |
| Mean Jacket Temp. | Deg. Fah. | 120·5 | 121·4 | 122·4 |

## Fuel.

The fuel used throughout these tests was supplied from one barrel of standard Royal Daylight paraffin. The oil was contained in a tank placed on the platform of a weighing machine, the scale of which was graduated to half-ounces. To this tank a fine adjustment needle-valve was fitted, through which the oil dripped into a small brass vessel fitted with a gauge-glass. The quantity of fuel was measured by opening the valve sufficiently to keep the oil-level in the gauge-glass constant, and timing the drop of the weighing-machine lever at different increments of loading.

### Cooling Water.

The jacket water was supplied from one or other of two calibrated gravity tanks. The temperatures at inlet and outlet were taken in thermometer pockets 6 in. from the inlet at the bottom of the water-jacket, and 3 in. from the outlet by the exhaust-valve.

### Revolutions.

These were taken from a counter driven off the cam-shaft.

### Load.

The load was applied by a rope brake, the ropes passing half round the flywheel and attached at the ends to two spring balances.

### General.

All the instruments used in the trials were calibrated, and in working out the results the corrections are taken into account. The engine was started up from two to two-and-a-half hours prior to the commencement of the test, and for an hour before the start was running under test conditions. The test records were taken by one person only, and readings were taken in pre-arranged order at definite intervals.

### Adjustment Made During the Trials.

(1) The valve on the cooling water inlet-pipe was gradually opened in order to keep the temperatures at inlet and outlet constant. This was necessary, since the reduction in head as the surface of the water sank in the gravity supply-tanks lessened the amount of water passing in a given time. This adjustment was not needed for the half-load trial and only slightly for the three-quarter load trial.

(2) The valve on the second stage injection air-compressor cylinder outlet was adjusted to keep the blast-pressure constant, as the compressor output varied with the lubrication.

(3) The spring balances were observed, and a constant difference maintained between their readings. No lubricant or cooling medium was used on the flywheel during the test.

The results of tests at full load, three-quarters load, and half-load are given in Table 1. These figures are confirmed by many preliminary experiments.

TABLE 2.
FIGURES DEDUCED FROM TEST RESULTS.

| Units. | | Half Load. | Three-quarters Load. | Full Load. |
|---|---|---|---|---|
| Indicated H.P. | | 6·81 | 8·61 | 10·42 |
| Brake H.P. | | 3·89 | 5·73 | 7·57 |
| Lost H.P. by diff. | | 2·92 | 2·88 | 2·85 |
| Mechl. Effy. | Per cent | 57·1 | 66·55 | 72·7 |
| Heat supplied | ,, | 100 | 100 | 100 |
| ,, as I.H.P. | ,, | 44·6 | 43·9 | 42·1 |
| ,, to Cooling Water | ,, | 32·2 | 29·2 | 29·6 |
| ,, Exhaust by diff. | ,, | 23·2 | 26·9 | 28·3 |
| ,, as Brake Work | ,, | 25·5 | 29·2 | 30·6 |
| ,, as Friction | ,, | 19·1 | 14·7 | 11·5 |
| Main Air Charge | cu. ft. per cycle | 0·1818 | 0·1805 | 0·1802 |
| Oil per B.H.P. hr. | Lb. | — | — | 0·448 |

### Commentary on Apparatus and Test Results.

It will be noted that the quantity of air passing through the meter was somewhat in excess of the standardised capacity of that instrument, nevertheless the accuracy of measurement under the conditions given was stated by the makers to be within 0·5 per cent. The figures given for the weight of injection air used are probably not reliable within 5·0 per cent. In these trials the mean jacket-temperature was purposely kept approximately the same, in order to keep the cylinder charge-weight as constant as possible. The diminution in charge-volume with increasing load is then due mainly to the higher temperatures of the cylinder-wall at the larger loads.

*(To be continued.)*

## ELECTRICAL ACTIVITIES AFTER THE WAR.

By F. Ashton.

*(Continued from page 116.)*

There is also a field for enterprise in connection with agriculture. Sooner or later transmission lines or cables will be extended into rural districts, thus putting electric power at the disposal of those who work on the land. On the Continent of Europe and in America some of the electrical undertakings have very large agricultural loads, but in this country little attention has been paid to this important matter. At Hereford, however, a system of light transmission lines has been erected to reach agricultural consumers, and there is every indication of electric power being extensively used in the future. All engineers in charge of stations in the vicinity of rural parts should endeavour to build up agricultural loads at the earliest opportunity. When the facts concerning other countries are considered, it is surprising that British engineers should have delayed operations so long. But, of course, it has to be recognised that the conditions prevailing in this country are not quite the same as those that exist abroad. Where there are large water-power stations, for instance, the current is transmitted at very high pressures over long stretches of land to industrial and business centres, with the result that the lines can be tapped in country places. Transformers are provided at suitable spots for reducing the pressure to a value suitable for lighting and motors. At the same time many steam plants, more or less remote from farming areas, are, as the result of the provision of special transmission lines, supplying many units per year to farmers, and there is no reason why some of the stations in this country should not do the same. As an example of the extent to which a single rural station may supply a farming community, the rural station of Besswitz may be cited. The distribution system is 145 miles long, and the territory served is 102,000 acres in extent, of which 40,000 acres are cultivated with the plough. To this network are connected 180 motors and 5,000 lamps, with a total consumption of 1,300 kilowatts. California—a purely agricultural State—uses more power per head of population than any other American State. Canada also furnishes an interesting example of farm supply on the Ontario Hydro Electric Commissioners' extensive distribution system, and practical examples of a similar kind are to be found in Australia, New Zealand, and elsewhere. Electricity can be used advantageously for milking cows, kibbling corn, rolling oats, cutting chaff, ploughing, and in fact for every operation for which steam and internal-combustion engines are employed. Electric ploughing has been carried out in France, Italy, Sweden, and Germany,

and in every case the results have been perfectly satisfactory.

The supply of electricity to rural places will in all probability eventually lead to very interesting developments, not only in connection with power and lighting, but also with respect to promoting the growth of crops. Experiments have proved pretty conclusively that by electrifying the atmosphere plant growth can be accelerated. Different investigators have attacked the problem in different ways. The earliest investigators illuminated plants with electric light, and in certain cases the results were beneficial. Some have buried dis-similial metal plates in the soil, and short-circuited them so that the plates and soil form voltaic cells, whilst others have sent current into the plates from an external source. These methods, however, have not, on the whole, given satisfactory results. The production of a silent or glow discharge between an antenna and the soil is at present undoubtedly the most promising method of stimulating the growth of crops. Professor Lemström, of Sweden, was the originator of this idea, and it has since been investigated by Sir Oliver Lodge and other eminent scientists. In some experiments carried out in this country during the years 1912-1914 the current obtained from a 30-volt storage battery was supplied to an induction coil working in conjunction with Lodge rectifying valves, the current from the latter energising in turn an antenna erected over a field of potatoes. Each season it was found that there was a considerable difference between the weight of the crops lifted from the electrified and unelectrified areas. In 1912 the extra weight of potatoes, as a result of electrification, was 10 cwts. 3 qrs. 5 lbs.; in 1913, 13 cwts. 3 qrs. 21 lbs.; and in 1914, 1 ton 3 cwts. 2 qrs. 1 lb. Upon the field previously used for the growth of potatoes, experiments were made in 1915 with oats. The season was a very dry one, and there was a scorching sun. Nevertheless there was a conspicuous difference in the quantity of oats lifted from the electrified and unelectrified areas, and the oats treated suffered less from the prevailing drought. Upon this subject of stimulating the growth of crops by electrifying the atmosphere a great deal has been written, and in some cases extraordinary results are said to have been secured. Professor Lemström and others are said to have obtained results far more striking than those so far obtained in this country, but the work of these investigators cannot be dealt with here. The point to be emphasised on this occasion is that electro-culture is a matter worth looking into. It will not provide central stations with very heavy loads, for experience has shown that large areas can be electrified with a small expenditure of energy, but it is to be remembered that if farmers find that electricity is useful in connection with the growth of their crops, they may be more easily tempted to use electric light and electric motors. In some countries, notably America, electricity has also proved most useful on poultry farms. By heating incubators with electricity it has been found possible to hatch the eggs with remarkable rapidity. Moreover, under the influence of high-frequency currents the chicks are said to grow at an increased rate. Whilst it is possible that some of the American reports are fictitious, there can be no doubt that electricity can be profitably employed in connection with many farming operations, and central station engineers should lose no time in making themselves conversant with farmers' requirements.

There are, of course, many other electrical developments that have been retarded somewhat as a result of the war, but those mentioned are of considerable importance, and demand attention as soon as peace is restored. It is doubtful if any of the countries engaged in the conflict have progressed with their electrical schemes to anything like the same extent as this country. In connection with railway electrification, for instance, a great deal of work has been done. Electric trains have been set to work on the Bury to Manchester lines of the Lancashire and Yorkshire Railway, on the suburban lines of the South-Western and North-Western Railways, and on the Shildon to Newport branch of the North-Eastern. There has also been a certain amount of progress in connection with linking up electric-power stations, and other important work of this kind is shortly to be put in hand. During the war, this question of linking up has, as a result of the difficulty in obtaining new plant, received much more attention than hitherto. The advantages the scheme offers are economy in the amount of plant required, economy in working, improved load factor, and greater reliability. In this direction a great deal remains to be done. Even the linking up of all the most important London stations will involve a considerable amount of work and expense owing to the differences in frequencies and voltages. Linking up is at the present time of vital importance, and the work should be proceeded with without delay.

*(Concluded.)*

## BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

*(Continued from page 91.)*

HEAT TRANSMISSION.

### Water Circulation in Water-tube Boilers, Babcock and Wilcox Land Type.

Fig. 82 gives a section through this type of boiler. The water passes down the back header or downcomer, through the tubes and up through the front header or riser into the drum. Each group of seven or eight water tubes, which are in one vertical plane, are fed by a separate downcomer, and the water passes away through a separate riser. In this way each group of tubes are assured of a share of the water.

It will be obvious that on account of the more intense heat to which the lower tubes are subject the circulation and steam production in these tubes will have the highest value. Tests made on a boiler of this type and having a steam production of 5·25 lbs. per square foot of heating surface per hour, gave the water velocity through the water tubes as follows:—

| | | | | |
|---|---|---|---|---|
| Through the lowest row of tubes | | | 3·2 feet per second. | |
| ,, | 2nd | ,, | 1·95 | ,, |
| ,, | 3rd | ,, | 1·5 | ,, |
| ,, | 4th | ,, | 1·08 | ,, |
| ,, | 5th | ,, | 1 | ,, |
| ,, | 6th | ,, | ·9 | ,, |
| ,, | 7th | ,, | ·44 | ,, |
| ,, | 8th | ,, | ·108 | ,, |

It will be seen from the above figures that the velocity through the top row of tubes is very small, and as a matter of fact, with low duties and with boilers with more than eight rows of tubes, the velocity of the water in the top tube may be negative. In other words, the water in these tubes does not take part in the circulation at all, but under certain conditions actually flows back into the downcomer.

As these top pipes add little to the power of the boiler,

the tendency to-day is to reduce the number of rows over each other, but to get the requisite number of tubes by increasing the width of the bundle of tubes. In the early days of this type of boiler, it was common to get

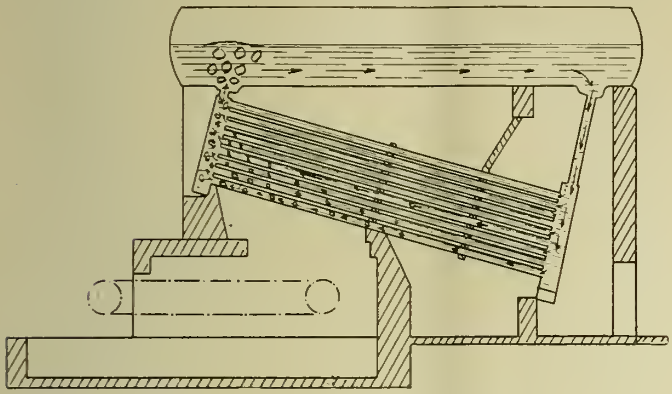


Fig. 82.—Boiler-House Efficiency.

fourteen tubes arranged over each other; to-day the number is seldom more than eight.

In such boilers great care is necessary in fixing the area of the riser and downcomer. The former must be of ample capacity to carry away the whole volume of water and steam issuing from its own group of pipes when working under minimum load. Any restriction of area or bends in the riser will produce eddy currents, which will hinder free circulation. In many boilers a deflector plate is fitted at the top of each riser. This plate is curved, as shown in the figure, and serves to assist the water in changing easily from the vertical motion in the riser to the horizontal motion in the drum.

With regard to the area of the downcomer, this must be amply sufficient to keep all tubes, and especially the lower ones, well supplied with water. Some makers arrange the connection of the downcomer to the drum to be a funnel shape, as shown dotted in the figure.

Another arrangement for the water connection is shown in Fig. 83. It will be seen that the water passes down the main vertical header *a* into the horizontal

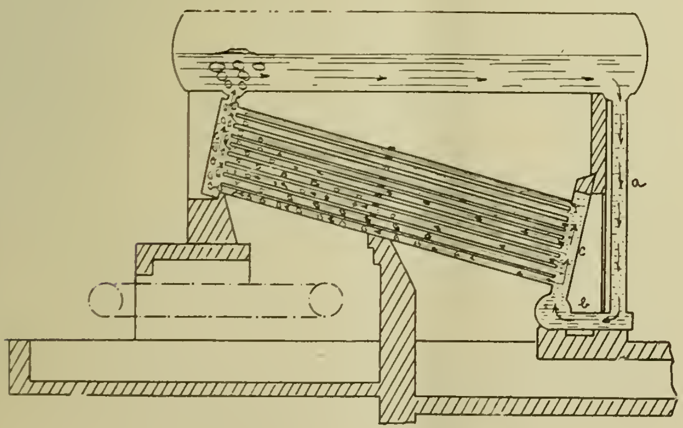


Fig. 83. Boiler-House Efficiency.

drum *b*, from which the riser *c* feeds the tubes. This arrangement has two advantages over that shown in Fig. 82, in that, first, the slower movement of the water in the pipe *a* and the change of direction at the bottom make more certain of the depositing of sediment before the water enters the tubes; and, second, the water supply is made much more secure to the lower tubes, where the maximum volume is required. The use of this separate large downcomer is meeting with increasing favour in this country.

### Babcock and Wilcox Marine Type.

In this type of boiler the water circulation is as shown in Fig. 84. The tubes being inclined in the opposite direction to those in the land type, and the fixing of the drum over the front header, causes the water to flow from front to back in the tubes. It will be especially noticed that there is no drum fitted over the riser, the mixture of water and steam coming from this having to pass through the horizontal tubes to the main drum in front of the boiler.

The two bottom rows of tubes in this boiler are usually

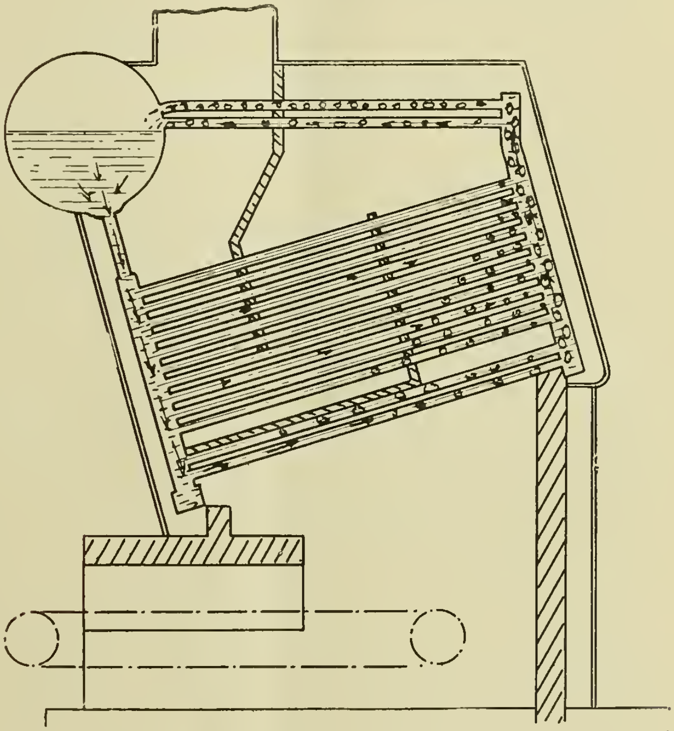


Fig. 84.—Boiler-House Efficiency.

made of larger diameter than the higher rows on account of the increased evaporation in the lower rows, and the desirability therefore of providing for a good flow of water. Sometimes in this boiler separate pipes are fitted on the outside of the boiler conecting the lower portion of each end of the drum with the end of the chamber at the bottom of the downcomer. In this manner an adequate supply of water for the bottom tubes is assured.

The freedom of circulation in the marine type is not quite so good as in the land type of Babcock and Wilcox boiler. The resistance to the passage of the mixture of water and steam from the riser into the top tubes must be considerable. This point, however, is more than compensated by the general good qualities of the boiler which holds the field in marine work and which is becoming more and more used for central station work.

*(To be continued).*

# ASCERTAINING FUEL VALUES.

## THE CALORIMETER SIMPLY EXPLAINED.

By F. R. Parsons.

### Heating Value.

The average engineer in charge of a steam-raising plant rarely concerns himself with the actual heating, or calorific, value of the raw material which day in and day out he so industriously shovels into the boiler furnace. If it is bad from a combustion point of view, or it gives undue trouble on account of much caking, or that it is productive of a deal more labour in the matter of cleaning fires, and so on, than usual, he will, with this *prima facie* evidence to go upon, complain loudly that the coal is "rotten," and condemn it as a worthless and uneconomical steam raiser. The true aspect as to whether it is high or low in calorific value is a matter altogether outside his calculations.

### Coal Selection.

The selection of a coal suiting the working conditions of a particular steam generator, a coal most economical in use, and productive of the greatest number of heat units per pound of it efficiently burned in the furnace. Consequently, ance to successful management. It is not, however, proposed in this short article to traverse in a comprehensively theoretical manner the ground covered by the consumption of fuel within a boiler furnace, but rather to explain in simple and practical language, so that any boiler attendant can understand, the practical working and construction of the instrument known as a calorimeter, and by which the heat values of coal, as a steam-raising medium, can be ascertained.

### Fuel Value.

In the first place, the value of any fuel is determined by the amount of water which can be evaporated by every pound of it efficiently burned in the furnace. Consequently the richer the fuel is in gaseous elements and the freer it is from non-gaseous elements, or residuals, the higher is its value for water-evaporating purposes.

### Fuel Consumption.

Closely allied to the quality of the fuel from a gas producing point of view is the manner in which it is consumed, since the very best of coal, unless favourably assisted by efficient furnace conditions, might well prove of less value for steam-raising purposes than a much inferior quality coal consumed under furnace conditions that are more favourable. At the moment, however, we are not so much concerned with the manner in which a fuel is consumed, our interest being centred rather in determining fuel values under existing circumstances.

### Determining Calorific Value.

One of the most usual, albeit, rough and ready methods of determining the calorific value of a coal is by measuring or weighing the quantity shovelled into a furnace during a given period, and also by measuring or weighing the amount of feed water introduced into the boiler during the same period. As can be imagined, this at the best is but a clumsy and very unreliable method of arriving at results, since no exactitude can be depended upon either in the quantity of fuel transformed into heat, the amount of heat wasted, or yet in the amount of water evaporated, as both steam-producing and steam-consuming conditions are of an ever varying character.

### The Calorimeter.

To suggest to the average boiler attendant that he could arrive at absolutely correct results by the use of an instrument termed a calorimeter would but confuse his mind with visions of mathematics, and nightmares of chemical and physical formulæ and phenomena. But it need mean nothing of the sort. The instrument mentioned is very simple in construction, easy to manipulate, and by its ready and accurate reading of results in giving the calorific power of a fuel almost directly in British thermal units opens up a highly interesting, and at the same time an extremely instructive field of research.

In principle the calorimeter, or at least one familiar form of it, is not unlike a large thermometer, in the bulb of which combustion of the fuel undergoing examination takes place, the heat being absorbed by the liquid within and around the bulb. Attached to the latter is a glass tube containing a column of liquid, and the absorption of heat is proportional to the height to which this column of liquid rises. This bulb is really the combustion chamber, the fuel to be tested being consumed therein. In order to provide the necessary elements to promote combustion within a closed vessel a tube is led to the chamber carrying a supply of oxygen, and the products of combustion are passed out at the top through a spiral tube to another chamber fitted with a syphon gauge, which indicates the pressure of the gases with the bulb, 8 in. to 10 in. of water pressure being about the usual amount recorded.

Surrounding the bulb is a closed chamber containing a measured quantity of water, and connected by a glass tube, to which is attached a scale, means being provided for adjusting the zero level in the glass tube to any desired point. Into the bottom of the combustion bulb is fitted a plug, the removal of which permits the insertion of a small dish, or tray, in which is placed the powdered fuel; electric wires connected to a battery also pass into the chamber by way of the plug. Combustion of the sample of fuel is promoted by a thin platinum wire which, when in circuit with the battery, becomes incandescent. The amount of coal usually tested is from one to two grammes. This is dried to exclude moisture, finely powdered in a mortar, and carefully weighed. It is then introduced into the bulb of the calorimeter, connection made with the battery, and the platinum wire, which can be adjusted either above or in contact with the coal in the dish, is lifted clear for a time. Directly the water in the glass begins to rise, on account of the heat imparted to it by the incandescent platinum wire, oxygen gas is admitted to the combustion chamber, and the charge of fuel is fired by bringing down the heated wire to touch it. The instant the coal is lighted the current from the battery is broken, and the scale read and noted; the difference between the first and subsequent reading, the latter being got as the fuel is burning, denoting the actual reading. Actually, it is the released gases giving up their heat in passing through the water which determines the heat value of the fuel.

Of course, there are several minor details in connection with a test which require to be understood, one being the obtaining of the necessary calibration curve, in order to compare the coal test with the results obtained when pure carbon is consumed, and which constitute the standard of measurement. But once followed through, watching a test made by one familiar with the process, any intelligent engineer, provided with the necessary equipment, should be able to test quite readily a sample of the various coals provided for his use.

As something of a guide when comparing coal values, it may be said that pure carbon when consumed gives about 14,000 British thermal units per pound; this providing the basis upon which all coal values are compared.

# WEAR AND TEAR OF FUEL ECONOMISERS.

By Edward Ingham.

## The Functions of Fuel Economisers.

The fuel economiser, consisting essentially of a number of vertical cast-iron pipes placed in the path of the hot gases flowing from the boilers to the chimney, is nowadays almost invariably installed in connection with the steam plant at all large mills and factories, its object being to utilise a portion of the heat in the waste gases for heating the feed water. The apparatus will generally effect a saving of fuel of at least 10 per cent. and in many cases 15 per cent. providing it be maintained in good working order.

The fuel economiser, like the steam boiler, is liable to deteriorate as time goes on, and the rate at which the deterioration is allowed to take place determines, of course, the working life of the vessel. When the conditions of working are satisfactory there is no reason why an economiser should not work satisfactorily for 20 years; when they are unsatisfactory the vessel may be worn out in a few years.

The principal causes of deterioration are internal and external corrosion.

Internal corrosion, or wasting of the internal surfaces of the pipes, is caused by the action of the feed water. In most cases the wasting appears to be due to the presence of acids in the water, which attacks the iron of which the pipes are principally composed. The obvious remedy is to treat the water, before passing it into the economiser, with certain reagents which will neutralise the acids and so prevent the wasting action.

In the case of steam boilers, it is generally recognised that if the feed water be pure, internal corrosion, with the exception, perhaps, of a little isolated pitting, is not likely to be experienced. This, however, is not the case with fuel economisers. Experience has shown that a special form of wasting known as graphitic wasting is liable to take place when the water is very pure. This form of internal corrosion is a peculiar and a dangerous one, because the internal surfaces show no signs of wasting, and the defect is therefore liable to be overlooked. To all appearances, the pipes are of the original thickness, but on applying a chisel, the wasted material may be easily pared off.

## Graphitic Wasting.

A striking instance of graphitic wasting is recorded in the "Journal of the Society of Chemical Industry," 29 (1910), 1,141. In this instance, the cast-iron pipes of a Green's economiser were dissolved away within a few months, only a thin outer shell remaining. About 84·5 per cent of the iron, and the whole of the combined carbon and silicon, had disappeared, and a residue remained in the pipes containing the whole of the graphite, phosphorus, and silicon, the latter as oxides, which formed a thick layer of plumbago-like material on the inside of the pipes. The water which had been used was the town water of Sydney, N.S.W., which is a very soft one.

Graphitic wasting does not occur when the feed water contains much scale-forming matter in solution, because then the pipes become covered with a layer of scale which serves to protect the internal surfaces from the action of the water.

External corrosion is caused by allowing the external surfaces of the pipes and boxes to become damp. Accumulations of water, for example, in the bottom of the soot chamber will give rise to general dampness about the economiser, and consequently more or less general wasting of the external surfaces. Similarly, leakages from the cap joints, or drippings from the engine which drives the scraper gear, will cause external corrosion.

## Principal Cause of External Wasting.

The principal cause of external wasting of fuel economisers is, however, condensation of steam and vapour contained in the waste gases which pass through the economiser chamber. The water at the inlet end of the economiser is comparatively cold, and the vertical pipes which contain it consequently present comparatively cold external surfaces to the waste gases. The result is that the steam and vapour contained in the gases condense on the pipes, and so tend to cause external corrosion. This tendency to corrode the pipes is, however, greatly aggravated by the fact that the waste gases frequently contain certain gases which, in combination with moisture, from corrosive acids, and these acids cause rapid wasting of the pipes.

The trouble may generally be prevented, or at least minimised to a large extent, by a judicious adjustment of the feed water inlet temperature. What is required is to avoid sending the water into the economiser at too low a temperature. If the temperature be raised to 90 or 100 deg. Fah., condensation, and therefore corrosion, are not likely to take place, although in some instances trouble has been experienced when the temperature has been raised considerably above 100 deg. A convenient way of raising the temperature of the water the desired amount, in cases where this is necessary, is to connect the delivery pipe from the economiser with the suction pipe of the feed pump by means of small wrought-iron piping, so that some of the heated water from the economiser can be mixed with the cold water going to the feed pump. A small valve placed on the pipe connection will, of course, be required for controlling the quantity of the heated water flowing through the connection.

In view of the fact that the pipes of a fuel economiser are liable to waste both internally and externally, it is very important that the economiser should be thoroughly examined periodically by some competent person with the object of detecting any corrosion which may have taken place, and remedying it before it becomes serious.

## Some Erroneous Beliefs.

The importance of this is not always realised as it should be. Many seem to think that because an economiser consists principally of a number of pipes of only 4 in. internal diameter, there is little likelihood of an explosion taking place, since a small pipe is capable of withstanding an enormous internal pressure, and further, even should failure occur, the results cannot be serious owing to the fact that the pipes contain water and not steam.

Both these beliefs are erroneous. In the first place, whilst it is true that a small pipe of, say, $\frac{1}{2}$ in. thickness requires an extremely high pressure to burst it, it has to be remembered that since the pipes are liable to suffer, both from internal and external corrosion, the thickness of metal may be reduced in course of time to such an extent that the pipes are no longer capable of resisting the pressure imposed upon them. It has also to be borne in mind that there is always a possibility of a pipe's being cast eccentrically, so that at one part of the circumference it may be much under its intended thickness.

With regard to the belief that, even in the event of failure taking place, the results cannot be serious owing to the fact that the pipes contain water, and not steam, those who indulge in this belief probably forget that the temperature of the water in an economiser is generally well above 212

deg. Fah., so that should failure of a single pipe occur, some of the water will instantly flash into steam, the expansive force of which may be sufficiently violent to cause failure of other pipes, and disruption of the whole economiser may thus take place. As an actual instance of this, we may refer to an explosion which occurred a few years ago in South Wales, when one section (96 pipes) of an economiser of 192 pipes was so completely shattered that it could not be reassembled.

### Examining Fuel Economisers.

Unfortunately, it is a most difficult matter to make a satisfactory examination of a fuel economiser, owing to its inaccessibility. The whole of the pipes are more or less inaccessible, so far as internal examination is concerned, and the most that can be done is to drop a lighted candle, or a small electric glow-lamp, down the pipes, and note the internal condition, as far as possible, by this means. Obviously, this is very unsatisfactory.

So far as external examination is concerned, only the outer rows of pipes are accessible, but fortunately the pipes most liable to suffer are those in the outer rows at the inlet end of the economiser. The extent of the wasting here can be determined by calipping the external diameter of the affected pipes, and comparing this with the original diameter. It is not advisable to allow the diameter of any of the pipes to become reduced to less than 4 $^3/_{16}$ in.

In order to ascertain definitely the general condition of an economiser, the only really satisfactory means of doing this is to withdraw a pipe here and there, and either drill a hole through the part where the wasting is suspected to be most severe, or else break up the pipe. The exact thickness of metal remaining, which, of course, determines the strength of the economiser, may then be determined with certainty.

This procedure is, of course, a costly and an expensive one, and few firms will adopt it. Hence boiler insurance companies frequently advise the application of a hydraulic test in cases where an economiser is believed to be in a wasted condition. Such a test, when carried out under the supervision of an expert, will often prove useful in discovering seriously wasted and defective pipes, but it can never be regarded as a satisfactory substitute for visual inspection. There is always the possibility that the application of a water pressure much higher than the ordinary working pressure may aggravate defects without revealing their existence. Nevertheless, when judiciously applied, the hydraulic test is of great value as an aid to visual inspection. It is important that the pressure should be maintained for a time, say half an hour or thereabouts, because experience would appear to show that failure of weakened parts is most liable to occur some time after the pressure is first applied.

### Overheating and Water-Hammer.

In addition to internal and external corrosion, overheating and water-hammer are sometimes responsible for deterioration of fuel economisers. Both overheating and water-hammer are generally the result of want of care on the part of those responsible for the working of the economiser. Thus, when starting up in a morning, an attendant will sometimes disregard the fact that the engines are not yet working, so that steam is not being taken from the boilers, and consequently the water in the economiser is stationary. The furnace gases, therefore, instead of being by-passed direct to the chimney, until the engines are started, may be passed through the economiser chamber. Under such circumstances, the water in the vertical pipes may eventually be raised in temperature to such an extent that steam begins to form, in which case the water-level will be lowered, and in consequence the upper portions of the pipes become overheated. Risk of fracture, and even explosion, is then involved.

The steam formed in the upper portions of the pipes may set up water-hammer by coming into contact with the water in the feed-pipe between the economiser and the boiler when the stop valve on the pipe is opened.

Hence, when starting up, it is doubly important that care be taken to pass the furnace gases, or at least the bulk of them, direct to the chimney.

It will be gathered from what has just been said that intermittent feeding may also result in overheating and water-hammer, because at times the water will remain stationary in the economiser, and steam is then liable to be formed. Hence the importance of feeding regularly and continuously. In conclusion, it may be mentioned that overheating, fracture, and explosion have in a few instances resulted through heavy accumulations of scale in the pipes. Such accumulations, besides impairing the efficiency of working, are bound to cause serious straining of the pipes, which leads to unnecessary wear and tear

## FRICTION CLUTCHES.

By William G. Gass, M.I.M.E.

(*Continued from page* 108.)

### Clearances.

Clearance is the main difficulty in the general run of clutches, and the smallness of it is the cause of a considerable amount of wear when running out of gear. In all cases where the setting up is done by screws, the clearance between the driving part and the driven is a relatively small amount. The cone gives the largest amount of any, and on that score alone is the best. In segment clutches both inside and outside band clutches, and plate clutches, it is a very serious problem. In the majority of these, where a screw is used, the usual amount of rotation of the screws is about one-eighth of a revolution, and if screws of, say, $\frac{1}{4}$ in. pitch are used, right and left hand, the movement given to the segment is $^1/_{16}$ in.—*i.e.*, $^1/_{32}$, on each side, and that represents the clearance when the clutch is out of gear; the actual clearance is less than this owing to the shape of the segments.

Attempts have been made to increase the clearance by racks to rotate the screw through a pinion, but this does not enable the necessary pressure to be put on the screw, and there is consequently a loss in efficiency. In the internal-band clutches, or those of the all-metal spring centre type, the movement is less than in the segment type, as the metal will not stand the same amount of movement. In plate clutches it is even less, but these do not need quite so much movement. Usually these are not set up by screws, but by the direct thrust from a toggle lever, and when the clearance is divided over a number of plates it is small, and there is consequently some rubbing when the plates are running out of gear, though it does not seem to have an appreciable effect, except at high speeds. In magnetic clutches the clearances must be small or the magnetic efficiency is greatly reduced.

Generally speaking, clutches of all kinds wear away more quickly out of gear than they do in gear, even where they are strong enough to easily cope with the load. Clearances are, therefore, the weak spot in almost all types of

clutch, being so small that any wear which occurs in the bushes of the free part of the clutch affects its running, and throws the two portions out of line. This is a serious matter in large clutches, as the ratio of clearance is not in proportion to their diameters, being relatively less with the large size than with the small. Heavy segment clutches running at slow speeds are sometimes supported by external rollers to assist in keeping the outside of the clutch in line. The question of clearance only arises when the clutch is running out of gear.

### Setting up Gear.

In all cases the action of setting up a clutch is the conversion of a sliding movement along the shaft carrying the clutch into a pressure between the clutch surfaces. This may be properly divided into two portions, the first that which is in the clutch itself, and the other that by which the power for operation is applied. In the majority of clutches the locking and concentration of power obtained by the toggle motion is the one mostly adopted, and when once set up has no tendency to slip back. It requires in every case an adjustment by means of a screw which can be set so as to bring the levers in the correct position to give the requisite pressure on the surface.

In most of the internal and external segment and band clutches the adjustment is obtained by moving the main nuts a portion of a revolution and re-locking, the nut having a serrated rim with a locking pin. In plate clutches it is generally done by using the adjustment screw at the point where the pressure to the plates is applied. In others the forcing of the surfaces in contact is done by a wedge, having at its larger width a parallel portion which takes the end thrust off when the clutch is set up. This wedge is flat in some and circular in others.

With both the toggle joint and the wedge a sliding block is necessary to transmit the power from the stationary lever to the rotating shaft carrying the clutch. In the majority of cases the power is applied to the clutch to set it in gear, but, in others, the power is applied to release it or put it out of gear, the clutch being kept in gear by means of springs. Motor-car clutches are the most common examples of this kind. For general machine driving, where a rapid movement is required for operating the clutch, a lever is usually employed, and if the leverage is sufficient, is quite satisfactory. It enables the power to be applied quickly and as quickly released, and where it is desired to give a slight movement to the machine, and also where the clutch is put in gear and released many times. But where a clutch is in gear for long periods a screw and quadrant is mostly used. This is as generally fitted to internal-combustion engine drives. It gives an easier starting movement because the pressure can be more gradually applied, but it is much slower both at starting and releasing. Where the lever is used, particularly on a heavy clutch, it requires a strong pull on the part of the attendant to put the clutch in gear. The trouble with all setting up gears is the wear on the pins and lost motion due to clearance in bearings.

### Pressure on Working Faces.

This is the crucial point in the efficiency of any clutch and its power to drive, for unless the necessary pressure exists between the frictional faces the clutch cannot transmit its power, and it is here where so much trouble arises in the use of any form of friction clutch. The power of any clutch is, of course, dependent on the coefficient of friction between the surfaces, and whether they are dry or lubricated, and it is this factor which so materially affects any formulæ for the power of a clutch. There is no difficulty in saying that any clutch should transmit so much power, provided we assume that a certain pressure exists between the surfaces; but there are many very small items which will affect the result, more particularly where the surfaces are metal to metal. The coefficient of friction varies greatly with the state of the surfaces, and after the surfaces become glazed with use it drops very quickly, and the power of the clutch drops in unison.

It is usually considered that if an actual pressure of 50 lbs. per square inch can be put on the surfaces it is as much as is desirable for good working conditions; but, if for any reason a less pressure is put on than that required to transmit the power, a clutch will, if it begins to slip, grind itself away quickly, and in the spring-centre type grind away all the available spring in the metal. On looking at the action of the toggle joint it will be seen that the travel of the portions of the clutch being set up is very slight at the end of the movement, when the thrust link of the toggle is approaching the vertical.

Pins are essential, and in spite of all that can be done, will wear so that if a clutch is set up correctly a very small wear on the pins and links of the toggle will rapidly reduce the effective pressure of the faces, even without taking into account the wear on the frictional surfaces. It is, therefore, very necessary to keep a watch on a clutch to see that any wear which may take place is followed up, if the life of a clutch is to be as long as it ought to be.

Where the pressure on the surfaces is due to springs, and these, as they usually are, are in direct thrust, then they will follow up a considerable amount of wear themselves. It appears from this as though springs were the best, but they are only good where conditions are suitable, and this is not generally so for driving machines. The remarks about wear apply equally to wedge setting up surfaces.

The power transmitted is proportional to the speed of rotation, and a clutch which will transmit 10 H.P. at 100 revolutions will, of course, transmit 50 H.P. at 500 revolutions. The point, therefore, that has to be observed in using a clutch is to see that the pressure necessary to do the driving must always be maintained, if the friction clutch is to do its work satisfactorily, and that allowance must be made for the wear of pins, and other parts, in the adjustment of the setting up gear.

*(To be continued.)*

## THE INTERNAL-COMBUSTION ENGINE.*

By Dugald Clerk, D.Sc., F.R.S., M.Inst.C.E.

Motive power is of fundamental importance to industrial civilisation: without steam, internal combustion, and hydraulic power it would be impossible to support at all the 46 millions of people now living in fair comfort on our small islands of Great Britain and Ireland. The labour of the scientific man, the engineer and the business man, in the long run, renders possible the very existence of this large and dense population.

The important part taken by us in the origin and development of steam motive-power is well known, and it is generally recognised that Britain stands supreme in all that relates to steam engines from the time of the condensing engine of James Watt to the steam turbines of the Hon. Sir Charles Parsons. All the intermediate stages—expansion, high pressures, compounding, tripling, and superheating—originated in these islands. The application to

* Paper first delivered in the Town Hall, Newcastle-on-Tyne, on September 4th, 1916, at the meeting of the British Association.

pumping, mill-driving, marine navigation, and locomotive engineering began and developed here. Although the credit of steam invention is conceded to us, many of our general public and some of our engineers seem unaware of the leading part taken by England in that great field of invention covered by internal-combustion engines; they imagine that in this subject we are wholly indebted to Germany, and that the work of invention here is small compared to that of the Continent. This impression has arisen because of the indefatigable propaganda of scientific engineering Germany and the distinct bias to German methods shown by some of our prominent men. We are freely given to self-criticism, and no doubt in time of peace this characteristic is quite beneficial and useful in maintaining the desire to improve; but in times of war and change it is as harmful to underrate our own strength and achievements as it is to underrate the power of our enemies.

In the development of internal-combustion engines we have borne our full share of pioneer work. It is true that effort both in the past and present is more uniformly distributed among the nations in this field than in steam, but we hold our own in the competition towards more perfect thermodynamic methods and machines.

A very short review of the past will convince you that much has been done by England to develop engines fit for the great modern uses of stationary power production, land and water locomotion, and last, light and powerful engines for flight. The subject is one to which I have devoted much attention for the past 40 years, during which these engines have developed from mere toys of ½ H.P. to 3 H.P. to engines of the thousands of horse-power of to-day. During that time there have been produced heavy engines for stationary purposes, light engines for motor-cars and flight, and intermediate engines for ship propulsion—all with the characteristic burning of the combustible gaseous or vapour fuel within the cylinder instead of within the boiler furnace.

My interest in the gas engine—as it was then called—began at the end of the year 1876. At that date the only types of engine in operation were the non-compression engine of Lenoir and the non-compression free piston engine of Otto and Langen. In 1876 the Lenoir engine had practically disappeared from commerce; a number were at work, but the only commercial engine was the Otto and Langen. This was a cumbersome engine, which operated with great noise and much recoil, and the largest of the type in existence did not develop more than 3 B.H.P. In that year the user of motive power had but little choice. He was practically confined to the steam engine, both for small and large powers. The motive power user of to-day is in a more fortunate position. Constructors of many types of motors compete for his favour.

These 40 years have seen a marvellous development of the gas engine, and an extension of the use of different fuels has caused the old title "gas engine" to disappear in favour of the more general term "internal-combustion motor," lately shortened to "combustion motor," which includes all engines known as gas, petrol, and oil motors.

The gas engine originated, as its title shows, in a form of machine adapted to burn the coal gas of our towns; for many years past other inflammable gases have been consumed, such as producer gas in its various forms, generated from anthracite, coke, bituminous coal, and waste combustible solids like wood chips, sawdust, spent tan, and cocoa-nut shells, also coke-oven gas and blast-furnace gas; light volatile hydrocarbons are used, such as petrol and benzol; heavy hydrocarbons and sometimes coal tar. Even alcohol is applied to the purpose of actuating such engines.

In 1876 the total power generated by gas engines in the United Kingdom did not exceed 2,000 B.H.P., while in 1907 the final report of the first census of production of the United Kingdom shows that factories alone had at work a total of 680,177 H.P., while agriculture employed 98,785 H.P. of gas, petrol, and oil engines.

In addition to this there were in use in motor-cars and motor-cycles not less than 750,000 H.P. generated by petrol engines. The total power generated by internal-combustion was thus:—

| | Horse power. |
|---|---|
| In factories, stationary gas, oil and petrol engines | 680,177 |
| For agriculture, stationary gas, oil and petrol engines | 98,785 |
| For motor-cars and cycles | 750,000 |
| | 1,528,962 |

In the United Kingdom a total of over 1½ million horse-power combustion engines thus existed in the year 1907.

An inquiry made in Germany in the same year showed a total of 351,000 H.P. of stationary combustion engines in operation in factories, and the total number of motor vehicles in use was 27,026, of which about one-half were motor-cycles. The total power of the locomotive petrol engines was not more than 180,000 H.P.

The total power generated by internal-combustion was thus:—

| | Horse power. |
|---|---|
| In factories, stationary gas, oil and petrol engines | 351,000 |
| For motor-cars and cycles | 180,000 |
| | 531,000 |

In Germany a total of 531,000 H.P. combustion engines existed in 1907, a little more than one-third of the similar power of the United Kingdom.

The census of production of the United States of America for 1909 shows that there were in use 1,299,021 H.P. of gas and gasoline engines for the stationary work of manufactures and mines.

Nearly 115,000 motor-cars were produced in that year; this, with the vehicles in use, required engines of a total of about 1·2 million horse power.

Total combustion power for the United States was certainly not short of 2·5 million horse power.

The internal combustion power in these three countries during 1907 and 1909 was:—

| | | Million horse power. |
|---|---|---|
| 1909. | United States of America | 2·5 |
| 1907. | United Kingdom of Great Britain and Ireland | 1·53 |
| 1907. | Germany | ·53 |
| | | 4·56 |

—over 4½ million horse power.

Allowing for the increase of Britain and Germany from 1907 to 1909, a probable value for the total combustion power of the three nations in 1909 is 5,000,000 H.P.

*(To be continued.)*

The Panama Canal.—At the end of the first two years' operation of the Panama Canal, which anniversary fell on October 27th, financial survey shows tolls amounted to £1,482,336, though the waterway was closed half a year by slides. In the two-year period a total of 2,097 ships passed through the canal. The heaviest draught vessel was the "Ohioan," drawing 29 ft. 4 in. of water.

# Trade Items, Notes, &c.

ANTI-CORROSIVE GREASE.—An anti-corrosive grease, readily soluble in benzine even at the end of several months, can be prepared by emulsifying an aqueous solution of chromic acid or chromates with hydrocarbons, sapouiable fats and oils, or the like. The fatty constituents serve as an adhesive, while the chromic solution prevents rusting, it is claimed. Equal parts of fat and a 5 per cent solution of sodium bichromate are triturated in a mortar. This makes a viscous paste which keeps iron plates bright for several months and is easily removable with benzine.

HYDRO-ELECTRIC PLANTS.—In many hydro-electric plants there is for some months of the year an excess of energy which is, to a large extent, not utilised. Use has been made of this excess by a Swiss company for raising steam in the boilers of a reserve plant. Electric heating elements are placed on the grate bars of the furnaces, from which they are readily removable when it is desired to fire with coal. The three boilers of the company's Zurich station furnish 12,390 lbs. of steam per day, with a consumption of 7,392 kilowatt hours, thus saving about 1,650 lbs. of coal.

THE construction of the new Trolhatto canal in Sweden has led to a series of other work in connection with harbours and waterways. It is now being urged that the canal between Lake Vänern and Lake Vättern should be improved so as to have the same depth and breadth as the new Vänern-Gothenburg waterway. At Kristinehamn extensive harbour works have been going on for several years, entailing an expenditure of some 4,000,000 kroner. The work is now completed, and the new harbour is about to be opened. The depth is 13 ft., and quays, store accommodation, and ample railway connections have been provided.

THE LARGEST FRENCH LINER.—The largest liner which has yet been built in France was launched on September 12th last from the Penhoet yard of La Societe Anonyme des Chantier et Ateliers de St. Nazaire. She has a length of 735 ft., a beam of 85 ft 3 in., while her moulded depth is 59 ft. 1¼ in. She has eight decks, and is furnished with turbine engines driving four propellers, there being one high-pressure, one intermediate, and two low-pressure ahead turbines, and two high-pressure and two low-pressure astern turbines. Steam is furnished by 15 double-ended boilers, 17 ft. 9 in. in diameter, having a working pressure of 215 lbs. per square inch.

FOREIGN AND COLONIAL MACHINERY.—The value of the exports of foreign and Colonial machinery from the United Kingdom in the first nine months of this year amounted to £367,423, as compared with £516,404 in the first nine months of 1915, and £796,009 in the first nine months of 1914. The total of £367,423 was made up as follows: Agricultural machinery, £15,180; boilers, £287; machine tools, £22,894; mining machinery, £7,331; complete sewing machines, £8,694; parts of sewing machines, £70,669; textile machinery, £8,793; complete typewriters, £72,862; parts of typewriters, £8,871; and unenumerated machinery, £151,842.

ELECTRO-CHEMISTRY AND GERMANY. The French journal *La Revue Electrique* reviews an article in the *Journal du Four Electrique et de l'Electrolyse* in which, it states, the author discusses what the part played by Germany in electro-chemistry really amounts to and shows that "there is nothing to justify the incommensurable vanity of the German pedants." German discoveries do not proceed from flashes of genius, but by a work carried out methodically and, so to speak, mechanically, a work which does not make any large demand upon intelligence. When the Latin genius has given effect to new ideas, these are defaced so as to enable the taking out of patents in the name of German laboratories. Germany is allowed to say that she is at the head of the industry in question, "simply because Borchers has written volumes on the subject, because her laboratory at Aix-la-Chapelle is an admirable one and its students have inundated the technical press with their heavy compilations." The article concludes by stating that the "famous German science is simply the modern mask of the most disgraceful barbarity."

U.S.A. TURBINE BUSINESS.—According to the *Electrical World* the volume of steam turbine business already handled since the beginning of the current year exceeds 2,000,000 kw. in rated capacity. At this rate the total 1916 business should reach 3,000,000 kw. in turbine capacity. The best deliveries that it is possible to obtain at the present time are eight months for some of the smaller sizes for pump and industrial use a year to a year and a half on large industrial and ordinary central-station sizes, and two years for the very large sizes. Orders now on hand are sufficient to keep the entire manufacturing facilities in operation for considerably more than a year. It has been roughly estimated that approximately 65 per cent of the present business is for central-station equipment, 25 per cent for industrial plants, including marine installations, averaging 300-500 kw., and 10 per cent for pumping stations averaging 50 H.P. Many large units have been ordered since the beginning of the year, the tendency being towards machines of very large capacity. Notable in this respect have been orders for a 73,000 H.P. and a 60,000 H.P. unit, and an order for two cross-compound units of a total rating of 95,000 kw. Both labour and material have been hard to obtain in satisfactory quantity and price, and both have greatly increased in price, with the result that turbine prices have advanced.

GERMAN WAR PROFITS.—The latest report of the Bochum Union for Mining and Cast-steel Manufacture states that the large output of the preceding year had been exceeded by 30,000 tons. A marked increase was also evidenced in the value of the turnover, because during the year no goods such as rails, sleepers, etc., had been manufactured, but almost exclusively products for direct and indirect war purposes. The plant had been heavily taxed, and 2,000,000 marks had been specially reserved on that account and for the transition period. The extension to the steelworks and blast furnaces, and the connection with the Rhine-Herne canal had proceeded during the year, but more urgent work had stood in the way of their completion. They were being proceeded with during the current year. The coal mines had worked most satisfactorily. Thanks to the excellence of the plant, the satisfactory financial position and the efficiency of the staff and men, the prospects were deemed promising. The dividend for last year was fixed at 25 per cent. The Charlotten Hutte, Niederschelden, Siegerland district, paid 16 per cent for last year, against 8 per cent for the previous year. The Westphalian Steelworks Company doubled its working profits, as also its production, during last year. The net profits amounted to 1,789,935 marks, liberal war-tax reserve and writings-off having been provided for, of which 20 per cent arrears on the preference shares were paid, various funds were well financed and 629,935 marks were carried forward.

THE Press Bureau has issued a circular to the effect that the Minister of Munitions has ordered the following:—

1. No person shall, as from the date hereof (December 8th), buy, sell, or, except for the purpose of carrying out contract in writing existing prior to such date, enter into any transaction or negotiation in relation to the sale or purchase of copper of any class, whether wrought or unwrought, situated outside the United Kingdom, unless such person is authorised by a special permit from the Minister of Munitions to purchase or sell the same. All applications for special permits shall be made to the Director of Materials, Armament Buildings, Whitehall Place, London, S.W., and be marked "Copper Permit," and all persons to whom such permits are granted shall observe and perform all the conditions subject to which such permits may be granted.

2. All persons shall, except as below mentioned, not later than December 16th, 1916, send in to the Director of Materials, Armament Buildings, Whitehall Place, London, S.W., returns of (*a*) all unwrought copper at the date hereof held by them in stock or otherwise under their control; (*b*) all unwrought copper due at the date hereof for future delivery to them; (*c*) all contracts existing at the date hereof for the sale to or purchase by them of unwrought copper.

Notwithstanding the above, no return is required from (1) any manufacturer or smelter of stock in hand or due for future delivery for the sole purpose of manufacture or smelting at his works; (2) any person whose total stock in hand and due for future delivery does not exceed two tons.

The Press Bureau has also issued a circular by which the Minister of Munitions gives notice (1) that as from the date of the Order (December 8th) he prohibits the use of copper, whether wrought or unwrought, in any kind of manufacture, except for the purposes of a contract or order for the time being in existence certified to be within Classes "A" or "B" of Circular L 33 as to control of output issued by the Minister of Munitions on the 31st day of March, 1916; (2) that the Order of the Minister of Munitions of November 6th, 1916, relating to the manufacture of copper wire and cable containing copper is hereby cancelled.

# New Companies Registered.

CHARLES SHAW AND SONS LTD. (145,496). Private company. Registered December 8th. Capital, £5,000, £1 shares. To take over the business of motor engineers, motor cab, car, omnibus and van proprietors and manufacturers, garage proprietors, etc., carried on by C. Shaw, H. Shaw, and A. Shaw at Barlow Moor Road, Chorlton-cum-Hardy, Manchester. Directors: C. Shaw, H. Shaw, and A. Shaw, each of whom may retain office while holding £500 ordinary shares. Manager: C. Shaw. Registered office: 98, Barlow Moor Road, Chorlton-cum-Hardy, Manchester.

HUBBARD BROTHERS LTD. (145,489).—Private company. Registered December 7th. Capital, £5,000, £1 shares (2,000 6 per cent cumulative preferred). To take over the business carired on by W. G. Hubbard at Basingstoke, Hants, as "Hubbard Brothers." Mechanical, electrical, hydraulic, and general engineers, millwrights, and smiths etc. Directors: A. Hubbard, R. S. Hubbard, and W. H. Hubbard. Qualification, £50. Secretary and solicitor: J. Smyth, Public Hall, Woking. Registered office: Reading Road, Basingstoke.

MIDLAND DYNAMO AND MOTOR REPAIRS LTD. (145,468).—Private company. Registered December 5th. Capital, £2,000, £1 shares. As title. Directors: B. Gill and G. Ward. Solicitor: W. Harding, 14, New Street, Leicester. Secretary: P Haynes, 8a, Pocklington Walk, Leicester. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

WEST RIDING ENGINEERS LTD. (145,481).—Private company. Registered December 6th. Capital, £500, £1 shares (100 deferred). Engineers, founders, smiths, machinists, manufacturers, tool-makers brassfounders, etc. Directors: A. Crowther, S. Parsons, B. A. Pickles, J. Wilkinson, and W. Armitage. Qualification, 50 ordinary shares. Registered office: 21, Prudential Buildings, Ivegate, Bradford.

ARTHUR BURN AND CO. LTD. (145,570).—Private company. Registered December 19th. Capital, £5,000, £1 shares. Stampers, tool and screw makers, manufacturers of hand and other grenades, shells, and cartridges, electrical engineers, manufacturers of metal parts for motor cars, motor cycles, and aeroplanes, etc. Directors: A. E. Burn (managing director and chairman) and E. Taylor (secretary). Secretary: T. H. Duffield, 21, Waterloo Street, Birmingham. Registered office: 55, Temple Row, Birmingham.

CORONA LAMPWORKS (NORTHERN) LTD. (145,612). Private company. Registered December 22nd. Capital, 10,000, £1 shares. To take over the business of electric lamp supply stores or depot carried on by "The Corona Lampworks Ltd.," and by J. Brown, their agent, at 156b, Briggate, Leeds, together with the agency rights, title, and interest in connection with the "Corona" brand of annealed-tungsten wire filament lamps. Registered office: 156b, Briggate, Leeds.

GEO. T. GREY AND CO. LTD. (145,588).—Private company. Registered December 20th. Capital, £10,500, £1 shares. To enter into a verbal agreement for the acquisition from the executors of G. T. Grey of the engine building and repairing business formerly carried on by him at the Holborn Engineering Works, South Shields, as a going concern, as from December 1st, 1915, at several prices, amounting in the aggregate to £5,444 15s. 3d., and to enter into a written agreement with J. Cocks, J. Bridge, Jane Grey, Ethel Alexander, Marian Waggott and G. T. Grey. Directors: Miss J. Grey, G. T. Grey, H. H Doeg, and W. A. Smith. G. T. Grey and H. H Doeg are joint managing directors. Qualification, £100. Solicitor: F. E. Hannay, North Eastern Buildings, Fowler Street, South Shields. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

RADIATOR TUBES LTD. (145,620).—Private company. Registered Dec. 22nd. Capital, £5,000, £1 shares. To take over from the Direct Copper Syndicate Ltd., a licence to work certain inventions and processes relating to the production of copper tubes for radiators. Directors: S. O. Cowper-Coles (permanent, subject to holding 100 shares) and others to be appointed by the subscribers. Registered office: 20, Copthall Avenue, E.C.

## FOREIGN (ENEMY) FIRM.

DECAUVILLE AND CO., 31 and 32, Broad Street Avenue, E.C., late 10, Eastcheap, E.C., makers of portable railways. Controller: George S. Pitt, 140, Leadenhall Street, E.C. (December 18th 383.)

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## APPLICATIONS FOR PATENTS

**From Dec. 4th to Dec. 16th, 1916 (inclusive).**

AKTIEBOLAGET SVENSKA KULLAGERFABRIKEN: Bevel gear-wheels. 17,416.
ANDERSON, A.: Coal-cutting machines. 17,671.
ANDERSON, BOYES, & CO.: Coal-cutting machines. 17,671.
ARMISTEAD, W.: Dynamo-electric machinery. 17,528.
ARMSTRONG, J. E.: Relieving excessive pressure in engine cylinders. 18,001.
BELL, G. G.: Water-heating systems, &c. 17,545.
BELL, R.: Power for driving engines. 17,558.
BELL, W. T.: Steam road compound engines. 17,689.
BRODERICK, E. N.: Carburettors. 17,427.
BROOM & WADE and BROOM, H. S.: Thrust bearings. 17,726.
BURDON, W. M.: Liquid-fuel furnaces. 17,721.
BARRAU, J. M.: Movable pallet pistons of rotary motors. 17,895.
BENTHAM, C.: Vacuum pumps. 18,090.
BERESFORD, R.: Variable-speed power-transmitting mechanism. 18,035.
BERGASSE, P. H.: Rotary internal-combustion engines. 17,995.
BIRCH, W. J. F.: Pistons of explosion engines. 18,068.
BRITISH THOMSON-HOUSTON CO.: Shaft-packing devices. 17,854.
BRITISH THOMSON-HOUSTON CO.: Producing alternating electric currents. 17,916.
BRITISH THOMSON-HOUSTON CO.: Methods of producing a high vacuum. 17,983.
BRITISH THOMSON-HOUSTON CO.: Systems of motor control. 18,095.
BUGATTI, E.: Valve distributing-gear. 17,858.
COCKBURN, D.: Gland. 17,576.
COSMO, J. DE: Explosion engines. 17,761.
CROSSLEY, C. W.: Rotary engines. 17,375.
CALDWELL, W. H.: Fuel supply. 18,065.
CAMPBELL, D. ST. C.: Steam-engines. 18,093.
CARMICHAEL, I. N.: Steam-engines, petrol engines. 18,093.
CHAPMAN, C. H.: Ball bearings. 18,060.
CLARY, E.: Valved coupling for fluid-pressure pipe systems. 18,023.
CLAYTON, L.: Tubular boilers. 18,043.
CLUNIS, R. R.: Rendering exhaust steam invisible. 17,942.
DARKER, A. H.: Dynamo-electric generators. 17,626.
DAVIES, A. J.: Water-circulating and steam-drying apparatus for boilers. 17,423.
DEIGHTON'S PATENT FLUE AND TUBE CO.: Tubular boilers. 18,043, 18,044.
DUTTON, J.: Furnace for steam-raising and smoke prevention. 17,956.
ENGLESSON, J. E.: Centrifugal governors. 17,871.
FERRANTI, S. Z. DE: Projectiles. 17,677.
FARLEY, J.: Rotary pumps. 17,771.
GALLOWAYS LTD.: Cylinders for uniflow steam-engines. 17,751.
GARBUTT, W. O.: Friction-wheel driving-gear. 17,707.
GILL, H. A.: Dynamo-electric machines. 17,451.
GILL, H. A.: Variable-speed generators and storage-battery systems. 17,452.
GENERAL ELECTRIC CO.: Shaft-packing devices. 17,854.
GENERAL ELECTRIC CO.: Producing alternating electric currents. 17,916.
GENERAL ELECTRIC CO.: Methods of producing a high vacuum. 17,983.
GENERAL ELECTRIC CO.: Systems of motor control. 18,095.
GRAND. H. H. BILLON-: Carburettors. 17,871.
HOLT, E.: Furnaces. 17,544.
JACKSON, W. J.: Yarn-winding machines. 17,668.
JACKSON, W. J.: Knitting yarn packages. 17,672.
JOLLY, J. C.: Carburettors. 17,634.
JONES, J.: Furnace grates and fire-bars. 17,723.
JONES, J.: Furnace fronts for steam-boilers. 17,876.
JONES, J.: Furnace grates and fire-bars. 17,877.
KELLY, T. D.: Internal-combustion engines. 17,868.
KILNER BROS.: Producer furnaces. 17,772.
KNOWLES, F. W.: Producer furnaces. 17,772.
LANDER, A. J.: Internal-combustion rotary engine. 17,692.
LANDER, C.: Internal-combustion rotary engine. 17,692.
LANGFORD, J. S.: Water, &c. heaters. 17,701.
LEWIN, W. J.: Tubular boilers. 18,044.
MCGEE & SON, W.: Pumps. 17,571.
MCVAIL, J. B.: Vaporisers for internal-combustion engines. 17,376.
MALKIN, E. A.: Clutches, pulleys, &c. 17,498.
M'COLL, K.: Steam-engines, petrol engines, &c. 18,093.
MCCONWELL & CO., A.: Furnace fronts. 17,876.
MCCONWELL & CO., A.: Furnace grates and fire-bars. 17,877.
MASCHINENFABRIK OERLIKON: High-power turbine plant. 18,033.
MASON, C. T.: Ignition dynamos. 17,987.
MATHOT, R. E.: Governing-mechanism for internal-combustion engines. 17,805.
MORRISON, D.: Reversible steam turbines. 18,042.
MORRISON, H.: Reversible steam turbines. 18,042.
NIBLOCK, F.: Water-circulating and steam-drying apparatus for boilers. 17,423.
OREM, F. S.: Internal-combustion engines. 17,643.
PAULIN, J. G.: Fluid-pressure indicator. 17,601.
PIAT, J.: Carburettors. 17,609.
PILLING, H.: Cylinders for uniflow steam-engines. 17,751.
PARRY, C. P.: Circulating water in steam-generators. 18,021.
REES, E. S. G.: Dynamo-electric machinery. 17,528.
RUCK, R. M.: Change-speed gear. 17,414.
ROBERTSON, W.: Hydraulic valves. 17,846.
ROSS, H. E. C.: Rendering exhaust steam or vapour invisible. 17,942.
SCOTT, D. T.: Water-tube steam-generators. 17,501.
SOC. DES MOTEURS SALMSON (SYSTEME CANTON-UNNE): Multicylinder motors with radially-arranged cylinders. 17,704.
SPURLING, A. B. C.: Internal-combustion engines. 17,565.
STOTT, R.: Internal-combustion turbines. 17,568.
STOW, C. E.: Air adjustment for carburettors. 17,473.
STRONG, P. R.: Interual-combustion engines. 17,565.

Seddon, W. H.: Rotary internal-combustion engines. 17,952.
Smal, F.: Carburettors. 18,043.
Soc. Française Radio-Electrique: High-frequency alternators. 17,937.
Soc. Lorraine des Anciens Etablissements de Dietrich et Cie de Luneville: Lubricating pistons of internal-combustion engines. 17,920.
Sphinx Manufacturing Co.: Ignition-devices for internal-combustion engines. 17,885.
U.S. Light and Heat Corporation: Dynamo-electric machines. 17,451. 17,454.
U.S. Light and Heat Corporation: Variable-speed generators. 17,452.
Walford, E. W.: Vaporisers for internal-combustion engines. 17,376.
Walls, A. G.: Pumps. 17,571.
Whitehead, A. R.: Clutches, pulleys, &c. 17,498.
Witt, J.: Valves for governing engines. 17,635.
Wiesengrund, B.: Toothed gearing. 17,947.

## COMPLETE SPECIFICATIONS ACCEPTED.

**1915.**

12,748—Chitty: Dynamo-electric machines.
13,152—Fasey: Internal-combustion engines.
14,026—Lancashire Dynamo and Motor Co., & Hargreaves: Electro-magnetically operated clutches.
15,825—Torrens: Carburettors.
16,423—Iddon, Iddon, & Iddon: Rotary disc valve for internal-combustion engines.
16,986—Schmidt: Cooling the pistons of internal-combustion engines.
17,265—Pickett, & Igranic Electric Co.: Remote control of apparatus driven by electric motors.
17,307—Vickers Ltd., McKechnie, & Clear: Pistons, piston-rods, and connecting-rods.
17,359—Keesing: Water-heater.
17,365—Barker & Anderson: Metallic packings.
17,501—Wright: Valves for internal-combustion engines.
17,552—Wade: Belt-shifting devices.
17,638—Carter: Packing rings for pumps buckets.
17,676—Lamb: Carburettors.
18,133—Pedersen: Furnaces for steam boilers.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

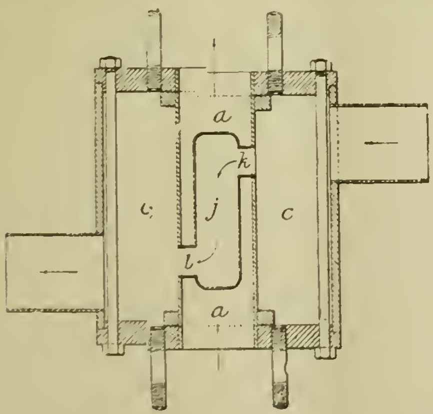
**1916.**

273—Hunt, W.: Rotary mechanism for the transmission of power. **102,514.**
430—Crossley, K. I., and Hutton, J.: Two-cycle oil engines. **102,517.**
700—Sanders, J. M.: Rotary engine. **102,520.**
1,216—Dreyfus, S.: Packing pistons. **102,527.**
3,046—Chedru, G. E.: Two-stroke internal-combustion engines with charging pump. **101,531.**
3,285—Shanks, J., and Gallagher, W.: Valves. **102,550.**
4,234—Watkins, G. St. B. S., and Funck, G.: Crank shafts for fluid-pressure engines. **102,555.**
4,918—Soc. Anon. Officine Meccaniche gia Miani, Silvestri, & Co., A. Grondona, Comi, & Co.: Steam turbines. **100,309.**
6,401—Waldron, N. B.: Centrifugal pumps. **102,571.**
6,589—Henderson, J. G.: Starting and stopping devices for electric motors. **102,434.**
6,702—Bellard, P.: Ball bearings. **100,780.**
6,830—Cross, W.: Flexible joints for fluid-pressure pipes. **102,435.**
7,504—Davenport, T. W.: Distributing-valves for hydraulic machinery. **102,404.**
8,353—Shira, J. A.: Converting rotary into reciprocating motion. **102,448.**
8,590—Williams, M. L.: Admission and exhaust pipes of internal-combustion engines. **102,584.**
9,245—Adams, C. H., and Rath, A. J.: Carburettor. **102,455.**

## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

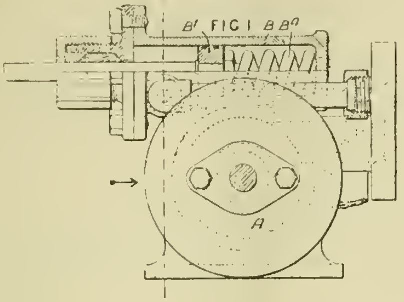
101,600.—R. P. Robinson, 259, Branstone Road, Burton-on-Trent, Staffordshire.—May 12th, 1916. No. 6824. Carburetted air passes

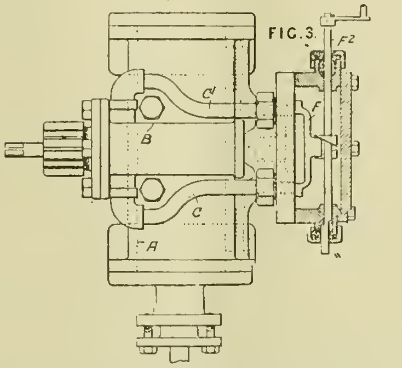



through a pipe *a* having an exhaust jacket *c*, and in its passage encounters a cylindrical chamber *j* which communicates with the jacket at *k l*.

### STEAM ENGINES.

101,851.—J. Blaylock, 30, Clara Street, South Benwell, Newcastle-on-Tyne.—June 26th, 1916. No. 8,975.—In an engine having a fluid-pressure actuated piston controlling a locking device which is automatically actuated prior to any actuation of the adjusting piston, the main and auxiliary pistons in cylinders A, B are jointly controlled by a single valve which admits fluid to, and exhausts it from, the auxiliary piston before the main piston.



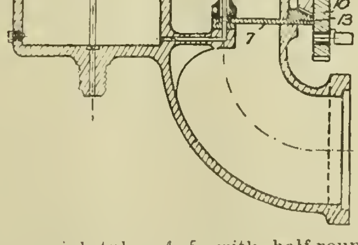




In the construction shown, the auxiliary piston B1 is pressed in one direction by a spring B4 and communicates on its other side with auxiliary ports in the main valve seat by passages C1, C controlled by connected lift valves actuated by the fluid pressure. The auxiliary ports are longer than the main ports, and both are controlled by a slide valve F actuated by spiral wedges on a hand-operated shaft F2.

### INTERNAL-COMBUSTION ENGINES.

11,023.—M. Egoroff, 31, Kozhevennaya, Vassily Ostroff, Petrograd.—July 29th.—The fuel nozzle is situated between two grooved drums 2 which are rotated in the same direction by gearing to vary the size of the passage 3 around the nozzle. The nozzle

FIG I

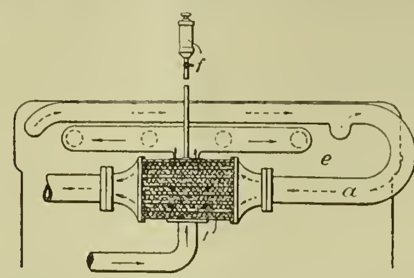



comprises two co-axial tubes 4, 5, with half-round outlets. The outer tube is adjusted angularly by a bevel-wheel 12, which gears with a rack 13 on the arm 7. The wheel 12 and the wheel 10, which gears with the pinions 11 on the drums 2, are moved together.

### INTERNAL-COMBUSTION ENGINES.

101,837.—T. W. H. Clarke, Denmark House, Ely, Cambridgeshire.—May 9th, 1916. No. 6,636.—Air carburetted with paraffin passes

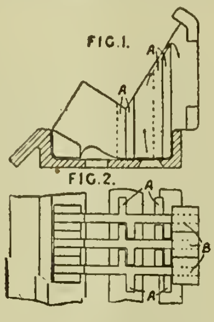
from the pipe *e* over the tubes of a multi-tubular vaporiser 1, and the exhaust gases from the pipe *a* pass through the tubes.




which are covered with gauze. Petrol, at starting, may be supplied from a sight-feed device *f*.

**FURNACES.**

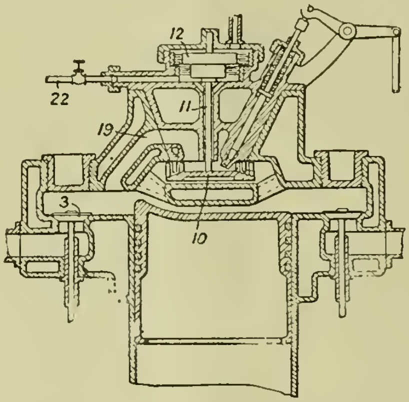
101,808.—J. NEIL, 93, Hope Street, Glasgow. Jan. 13th, 1916. No. 554.—In furnace bridges comprising longitudinal members such as are described in Specification 21,574/12, vertical flanges A are




provided on each side of the members B and arranged so that the flanges of adjacent members overlap.

**INTERNAL-COMBUSTION ENGINES.**

101,510.—A. SCHMID, Place Frederick Sauvage, Sainte Adresse, Seine Inferieure, France.—March 23rd, 1916. No. 4,349.—Convention date, Sept. 29th, 1915.—In engines having a turbine-like device 10 for mixing the fuel and air, a branch air passage 19 leads from




near the air-admission valve 3 to the interior of the turbine device, which may be driven by air escaping from the cylinder around the spindle 11 into an external turbine 12. Compressed air may be supplied by the pipe 22, or the spindle 11 may be extended and driven by an electric motor.



# INDEX TO ADVERTISERS.



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THE

# Industrial Engineer.

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# EDITORIAL.

## THE TRAINING OF ENGINEERS.

THE character of the education to be given to the youths of our nation, and especially to that section of them destined for the really practical work of life, has been, if not a favourite topic of discussion, at least both an interesting and exciting one. The subject has been pushed to the fore, like many other problems, by the European War. Indeed, the number of problems which have cropped up as a result of this war would seem to suggest that a good fight is really necessary to get something decent done in many directions. It certainly is true of a great many things, for there is no doubt whatever that we needed a sound awakening.

Amongst the subjects which demand most careful attention is the training to be given to our prospective young engineers. On this point the Manchester Association of Engineers (which is mainly composed of engineering employers, managers, and foremen, who foregather at intervals to discuss technical workshop problems) appointed some time ago a committee to go fully into the question. They have recently issued their report, and state that they found themselves confronted with three great difficulties: (1) The general lack of co-ordination among the existing technical schools and colleges; (2) the divorce of technical instruction from practice in the workshops; and (3) the lack of continuity in the education of the great majority of engineering employees.

They recommend that employers should insist on a boy's reaching a satisfactory standard of education before becoming an apprentice, there being no specialisation before the age of 14. All engineering apprentices should be given an opportunity to attend a school for two half-days a week from the beginning of their apprenticeship to the age of 17, and during this period there should be no evening classes, but the employer should pay the boy's wages for the two half-days, and thus retain his influence over him, the fees being specially reduced to a figure the ordinary apprentice could afford.

At the age of 17 the half-day schooling must in most cases cease, and the youths should be encouraged by their employers to attend evening technical classes two or three nights a week. Those deriving most benefit from the part-time classes should have an opportunity of passing an examination admitting them to a day course of, say, one day a week, and in every case the employer should reward them according to their progress in the works and the school, by offering special prizes or grants for industry and ability.

The committee think that in a scheme for engineering apprentices the engineering employers should have properly elected representatives. They suggest, therefore, that an appripriate number of employers' representatives should be elected by each of the large technical societies, and that these, with an equal number of technical representatives of the local education authorities, should form an advisory body dealing with all questions (other than finance) arising in connection with the education of engineering apprentices. In this way the co-ordination of the schools and the employers in each locality would be secured.

It is really astonishing how little we have advanced in the methods of technical education during the last 35 years when we come to consider the recommendations made by the Manchester Committee, for it must be remembered that most of our Technical Schools or Colleges have only existed in their modern form within the period referred to. It is quite true there has been no proper co-ordination between school and workshop in a general sense, though many praiseworthy attempts were made by such firms as Mather and Platt Ltd., of Manchester, to effect such co-ordination. That there will have to be much more general co-ordination is recognised, if we are to make and increase our progress, and this co-ordination will have to be enforced by compulsory means if necessary. There would be no harm in this, for there is no doubt that compulsion is often necessary to get our youths to progress on lines which is good both for themselves in particular and the country in general.

# TRIALS ON A DIESEL ENGINE, AND APPLICATION OF ENERGY-DIAGRAM TO OBTAIN HEAT BALANCE.

By the late Lieut. F. Trevor Wilkins (Northumberland Fusiliers), M.Sc., of the University of Birmingham, Graduate.

(*Continued from page 129*).

## Indicator-Diagrams.

A reference to the tops of the mean-indicator-diagrams. Figs. 3-5, shows pronounced differences at each load. The manner in which the spraying of the fuel affects the efficiency is shown at half-load, where it is apparent that the lower end of the spray-valve is not completely filled by the charge of fuel oil. It will be noticed that an appreciable time elapses before oil is blown into the cylinder and combustion begins. This is shown clearly on the energy-diagram. With increasing loads, since there is more oil in the fuel-valve, combustion begins earlier. Under these conditions, more oil is being injected than can be burnt immediately, and, as a result, after-burning takes place to a marked extent. At full load the combustion continues down the length of the stroke, whilst at three-quarter load the expansion more nearly approaches the adiabatic.

### The Diesel Cycle on the Energy-Diagram.

## General Remarks.

A short account of the construction and use of the energy-diagram is given in Professor Burstall's paper.* This paper includes an examination of the characteristics of the theoretical Diesel cycle when drawn on the energy-diagram. In the present paper the author considers the practical case only of the transference of actual indicator cards from an engine cylinder to the energy-diagram. To effect this transference the following information is necessary: the amount of the charge-weight and any two of the following four quantities, namely, pressure, volume, temperature, and internal energy. The charge-weight is measured during the tests; pressure and volume are deduced from the indicator cards. The charge quantities measured in the trials are, however, composed of several elements, whilst the energy diagram is drawn for 1 lb. of nitrogen. The charge quantity obtained on test must therefore be adjusted to obtain a weight of nitrogen, whose internal-energy changes will correspond to those of the substances in the engine cylinder

The volume of this equivalent charge-weight multiplied by the reciprocal of its weight will give the volume occupied by 1 lb. of nitrogen at the given pressure. It is thus possible to take a series of representative points on the indicator card, to transfer them to the energy-diagram, and to determine readily the changes in internal energy and temperature during the compression and expansion strokes. To explain the method more in detail, a representative point will be taken on the expansion line of the full load mean diagram.

## Detailed Method of Transference.

The weight of nitrogen equivalent to the charge-weight of air is determined from the fact that for such gases as oxygen, nitrogen and air, the product of specific heat and molecular weight is constant—that is:—

$$\frac{\text{Molecular weight of nitrogen}}{\text{Molecular weight of air}} = \frac{28}{28{\cdot}84}$$

$$= \frac{\text{specific heat of air}}{\text{specific heat of nitrogen}}$$

The weight of air drawn into the cylinder during the full-load trial = 0·01376 lb.

∴ equivalent charge-weight calculated to nitrogen

$$= 0{\cdot}01376 \times \frac{28}{28{\cdot}84}$$

$$= 0{\cdot}013358 \text{ lb.}$$

On the working stroke when the fuel-valve is closed there is added a small quantity of injection air and fuel oil. The weight of these is as follows:—

| | |
|---|---|
| Oil ................................ | 0·0004155 lb. |
| Air ................................ | 0·000629 lb. |

and are corrected to nitrogen in the same way as the air charge, thereby making of the full charge a nitrogen equivalent:—

| | | |
|---|---|---|
| Fuel oil { | Carbon ... . ............ | 0·000824 lb. |
| | Hydrogen .. ............ | 0·000872 ,, |
| | Injection air ........... | 0·000611 ,, |
| | Air charge ................ | 0·013358 ,, |
| | Total equivalent charge-weight = | 0·015665 ,, |

Turning now to the mean indicator-diagram for the full-load tests. Fig. 3, a point is taken where the piston

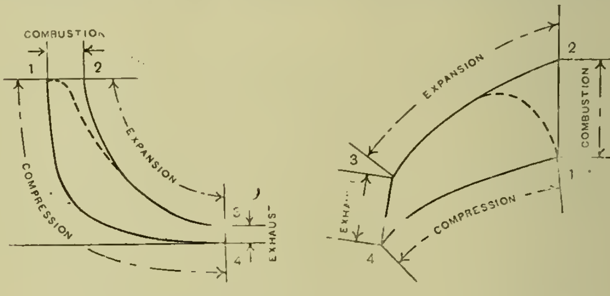



Fig. 6.—Comparison of Diesel Cycle on Indicator and Energy-Diagrams.

Theoretical Cycle ————
Principle Modification in Practice – — – – —

is at 0·15 of its stroke, the pressure in the cylinder is 337·7 lbs per square inch, and the charge occupies 0·042485 cubic foot.

The volume occupied by 1 lb. of nitrogen under the given conditions

$$= 0{\cdot}042485 \times \frac{1}{0{\cdot}015665}$$

$$= 2{\cdot}718 \text{ cubic feet.}$$

On the diagram a perpendicular is erected from the point on the pressure scale corresponding to 337·7 lbs. The intersection of this perpendicular with the constant volume line for 2·718 feet gives, when referred to other scales, the magnitudes of the internal energy and temperature of the cylinder charge.

To obtain the numerical value of the internal energy the

* The Energy Diagram for Gas, Proceedings, I. Mech., E., 1911, page 171.

value given on the diagram must be multiplied by the weight of the charge. For the point under consideration the values are:—

Temperature = 1·335° C. Absolute.

Internal Energy = 239·5° C. Thermal Units per pound.

redrawn indicator card, from which the following deductions may be made:—

Deductions from the Study of the Energy-Diagram.

## Deductions from Redrawn Indicator Card.

To render the redrawn diagram quite clear, the two

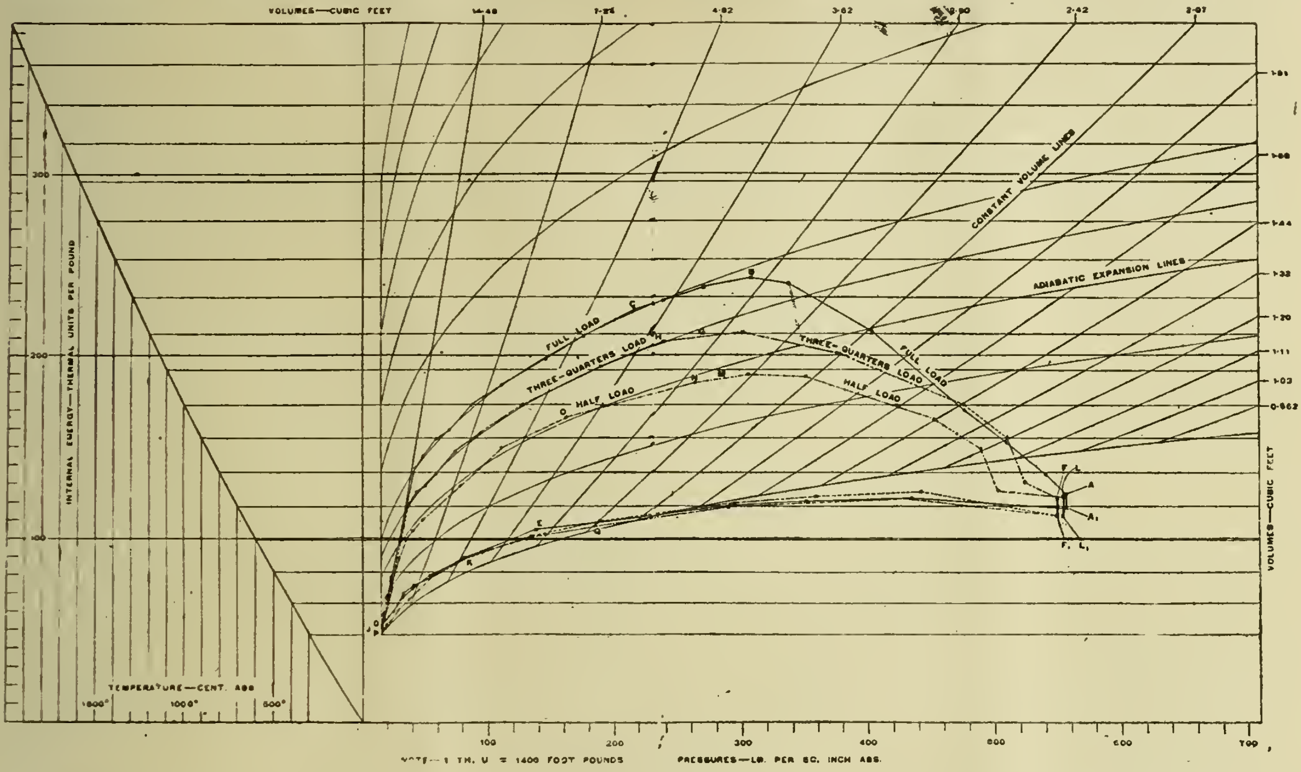



Fig. 7.—Energy Diagram.

The internal energy of the actual contents of the cylinder will be—

= 0·015665 × 239·5
= 3·752 Thermal Units,

or = 5,253 ft.-lb.

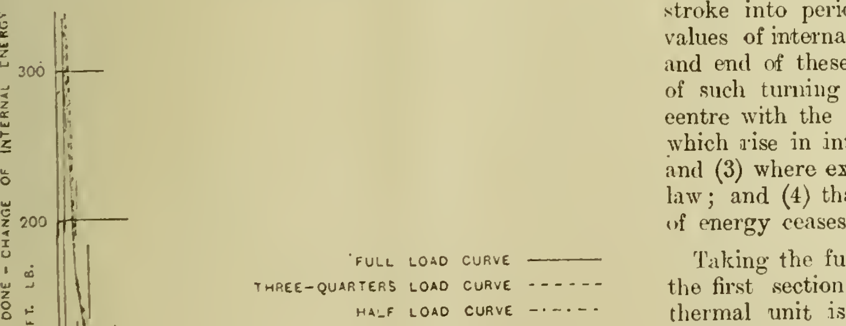



Fig. 8.—Heat Flow to Cylinder Wall on Compression Stroke.

By this method, points have been transferred throughout the expansion and compression strokes, and the result of joining up these points on the energy-diagram furnishes a

diagrams are shown side by side, Fig. 6, and each is numbered at the beginning and end of each operation in the cycle.

To investigate the manner in which heat transfer takes place on the expansion, it is instructive to divide up the stroke into periods, and to measure on the diagram the values of internal energy and temperature at the beginning and end of these arbitrarily fixed periods. The positions of such turning points are as follows: (1) at top dead-centre with the fuel-valve just opening; (2) the point at which rise in internal energy would seem to have ceased, and (3) where expansion commences to follow the adiabatic law; and (4) that point in the cycle where all the output of energy ceases and a new cycle commences.

Taking the full-load expansion stroke, it will be seen in the first section AB on the diagrams, Fig. 7, that 0·60 thermal unit is unaccounted for, or, rather, has either remained in the cylinder in the form of unconsumed fuel after the fuel-valve has closed, or else has passed out to the cooling water. It is probable that the greater part of this heat has been imparted to the cylinder-wall as in the next short section BC 0·107 additional thermal unit is required to make up the work to be performed by the piston. The work output during the successive periods of the stroke is determined by dividing up the original indicator-diagram by perpendiculars and planimetering the area lying between the expansion or compression lines and the line of zero pressure absolute. In the last section CD the expansion is

practically adiabatic, the work to be done by the piston almost equalling the fall in internal energy whilst a negligible amount of heat is supplied to the jackets. By arranging these figures suitably, it is possible to obtain the total heat-loss to the jackets during expansion and also the loss of heat to the exhaust.

The same process is followed for the three-quarter and half-load expansions, and the results are given in Table 3.

The compression strokes are treated in the same manner. In this case the turning point is taken at the place where the compression line makes a decided deviation from the adiabatic. Reference to the position of this point on the original indicator-diagram shows it to be within 15 per cent of the end of the stroke. It will be noted that the heat lost to the cylinder-wall during compression takes place entirely at the top of the stroke. This is also the case during the expansion stroke, and indicates that the heat given to the cylinder-liner for the major portion of its length is derived by conduction from the top of the cylinder and in an engine of the trunk-piston type from the side thrust of the piston upon the cylinder-wall. This effect is shown very decidedly by the curves in Fig. 8, which show the rate at which heat is transferred from the charge to the jacket and *vice versa*. These curves are drawn upon the information obtained by finding the changes of internal energy and work done over small fractions (1/60th) of the stroke and plotting these changes in the position in the stroke where they occur.

At present the opinion would appear to be that afterburning usually persists right down the expansion stroke.

TABLE 3.

Heat-Flow During Expansion.

| — | Description. | Derivation. | Full-Load Trial. | | | Three-Quarters Load Trial. | | | Half-Load Trial. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Period ........ | 1 AB | 2 BC | 3 CD | 1 FG | 2 GH | 3 HJ | 1 LM | 2 NO | 3 NO | 4 OP |
| 1 | Internal Energy of Charge at Start ...... | Energy Diagram | 1·70 | 3·81 | 3·52 | 1·62 | 3·20 | 2·98 | 1·64 | 2 89 | 2·82 | 2·53 |
| 2 | Internal Energy of Charge at Finish ..... | Energy Diagram | 3·81 | 3·52 | 2·08 | 3·20 | 2·98 | 1·75 | 2·89 | 2·82 | 2·53 | 1·44 |
| 3 | Heat Supply .......................... | Fuel Measurement | 4·3 | .. | .. | 3·36 | .. | .. | 2·62 | .. | .. | .. |
| 4 | Change in Internal Energy ............. | (2) — (1) | 2·11 | 0·29 | 1·44 | 1·58 | 0·22 | 1·24 | 1·25 | 0·07 | 0·29 | 1·09 |
| 5 | Work done on Piston .................. | Indicator Card | 1·59 | 0·39 | 1·40 | 1·62 | 0·23 | 1·20 | 1·21 | 0·16 | 0·43 | 0·99 |
| 6 | Total Internal Energy Change ........... | (4) + (5) | 3·70 | .. | .. | 3·20 | .. | .. | 2·46 | .. | .. | .. |
| 7 | Heat unaccounted for (Unburnt Fuel; Loss to Jackets) ........................ | 3 — (4) + (5) | 0·60 | .. | 0·04 | 0·16 | .. | 0·04 | 0·16 | .. | .. | 0·10 |
| 8 | Heat unaccounted for (Unburnt Fuel; From Jackets) ..................... | .... | .. | 0·10 | .. | .. | 0·10 | .. | .. | 0·08 | 0·14 | .. |
| 9 | Total Loss to Jackets on Cycle .......... | 7 — 8 | .. | .. | 0·54 | ... | .. | 0·19 | .. | .. | .. | 0·04 |
| 10 | Exhaust ............................. | Diagram. | .. | .. | 1·38 | .. | .. | 1·04 | .. | .. | .. | 0·94 |

TABLE 4.

Heat-Flow During Compression.

| — | Description. | Derivation. | Full-Load Trial. | | Three-Quarters Load Trial. | | Half-Load Trial. | |
|---|---|---|---|---|---|---|---|---|
| | | Period ......... | 1 DE | 2 EA | 1 JK | 2 KF | 1 PQ | 2 QL |
| 1 | Internal Energy at Start ................. | Energy Diagram | 0·70 | 1·63 | 0·70 | 1·68 | 0·70 | 1·64 |
| 2 | Internal Energy at Finish ................. | Energy Diagram | 1·63 | 1·64 | 1·68 | 1·625 | 1·64 | 1·69 |
| 3 | Change in Internal Energy ............... | (2) — (1) | 0·93 | 0·01 | 0·98 | 0·055 | 0·94 | 0·05 |
| 4 | Work done by Piston ................... | Indicator Diagram | 0·87 | 0·66 | 0·90 | 0·67 | 0·83 | 0·72 |
| 5 | Gain from Jackets ..................... | (3) — (4) | 0·06 | .. | 0·08 | .. | 0·11 | .. |
| 6 | Loss to Jackets ....................... | (4) — (3) | .. | 0·65 | .. | 0·72 | .. | 0·67 |
| 7 | Total Loss of Internal Energy ............ | (6) — (5) | .. | 0·59 | .. | 0·64 | .. | 0·56 |

The figures obtained from these diagrams show that at full load there is distinct after-burning in the second quarter of the stroke, but that in the last part more heat is passing from the charge to the walls than is supplied by after-burning. At half-load the heat which has gone to the cylinder-wall, when the piston is at the top of its stroke, is almost all repaid half-way down the expansion stroke.

(*To be continued*).

## FRICTION CLUTCHES.

By William G. Gass, M.I.M.E.

(*Continued from page 135.*)

### Lubrication.

In clutches, as in everything else, lubrication is of the greatest importance, and more particularly where the clutch is running idle for a considerable part of its time. If the outside portion of the clutch is the driven part, it runs on the shaft and may have to be stationary while the shaft rotates in the clutch bushes, or, if the outside is the driver, it has to run loosely on a stationary shaft. This is a fruitful source of trouble with many clutches, and the lubrication of these bushes requires the closest attention, both in design and on the part of the attendant. If the driven portion has to be stationary while the shaft runs in it, there is a tendency for the shaft to wear a groove in the bush, and when this starts it rapidly grows worse, as this part always seems to stop at the same point and be worn oval; while if the driving portion has to run loose on a stationary shaft the bush wears larger and affects the clearances, even sometimes becoming so bad that the friction surfaces never run clear and are always rubbing. When in gear the lubrication is not required, and the oil is liable to be driven out of the bearing surfaces and so be missing when it is wanted.

Many attempts have been made to arrange the lubrication in a satisfactory manner, and as good a way as any is to form a cavity behind the bush, which forms an oil well, and so stores up a supply; but the cavity is liable to become a receptacle for dirt and worn material from the shaft and bearings, and becomes a source of danger instead of benefit. Some makers emphasise the necessity of driving surfaces always running in oil, but a little consideration will show that while up to a certain point this is an advantage, yet it has evils which tend to counterbalance its advantages.

In starting up any friction clutch a certain amount of rubbing takes place, and when two metal surfaces rub on one another fine particles of metal are given off. These, in an enclosed chamber, cannot get away and so become mixed with the lubricant, and form an excellent abrasive which does not increase the life of the parts. This is, of course, obviated by a little care and the occasional cleaning out of the chamber, but as everyone knows, this is never done until something happens. Most clutch attendants work on the principle of letting well alone.

Another peculiarity of lubrication in the case of plate clutches is that where the resistance to the idle clutch is not very great, if the oil becomes thick, the plates adhere because all the air is driven out between them, and the resistance may not be able to make the clutch stop. Springs between the plates have been tried to get over this, but the results have not been very satisfactory. Excessive lubrication also reduces the driving power materially. Solid grease has much to be said for it for lubrication of clutch bosses, but it is often difficult to get it satisfactorily used.

### Application of Clutches.

In considering the question of the best kind or size of clutch to use for any particular purpose it is desirable to know the conditions under which it will have to work. Where the power is being transmitted to a machine from a line shaft to the clutch on a countershaft of a machine, by ropes or a belt, then the outside portion of a clutch is the driver, the rope or belt pulley coming on the boss. In this case an open type internal segment or band clutch is better to use than an enclosed plate clutch, not because one drives better than the other, but for a very simple reason. For this drive with the open type clutch the setting up screws would stop, and can be adjusted when the clutch is out of gear; while in the enclosed clutch the setting up screws would be running all the time and can only be adjusted when the main shaft stops, a matter of great importance if the clutch begins to slip, or requires adjustment for higher power while the shafting is running. But where a range of machines driven off one shaft by gearing is being used, then the enclosed clutch is handier for exactly the same reasons, the setting up screws stop and can be adjusted without stopping the shaft. This should always be seen to, viz., that whatever type of clutch is being used the setting up screws should be able to be adjusted at any time, without having to stop the main drive.

It is desirable to take into account the inertia of the machinery which the clutch has to put in motion. In some machines the starting load is considerably in excess of the working load, and therefore unless sufficient allowance is made in the power of the clutch there will be continued trouble. Take, for example, a heavy calender or mangle in a bleachworks. This, if the set or pressure be on the bowls, may put a starting load of 50 per cent or more on the running load, and the clutch must be able to overcome the initial load easily, or the clutch wears out quickly. Then, in mangles, say in a croft where there is a great amount of water splashing about, a cone if large enough will give as good results as any type of friction clutch.

There is also the question of the point of control: in any machine the starting lever of the clutch should be in such a position that the attendant can put the clutch in or throw it out of gear from the position he stands in when working the machine; long shafts spring a considerable amount, and should be as short as possible, but a lever and rod will allow for a moderate distance away.

When the point from which a clutch has to be operated is beyond the reach of shafts then the mechanical clutch meets with difficulties, and the magnetic clutch has an opening. But in remote control where the starting operator has not a good view, then there is a possibility of the machine being started when all is not clear and causing accident. This is not likely to occur when the starting operator is near his work and can see what he is doing. There is no difficulty, however, in operating mechanical clutches by compressed air or water power at any distance.

In driving machines that have very little inertia to overcome, like a fan or a dynamo, then it is necessary if a complete stoppage is required that the driven portion of the clutch should be carried on a sleeve, or be a clutch coupling, so that the friction of the bush cannot start the clutch rotating. A sleeve is, in effect, a hollow countershaft through which the main driver passes. As a coupling the friction clutch operates very well, the shafts carrying the driving portion of the clutch being distinct from the driven portion, and when in gear coupling the two shafts together. This is the usual method in coupling to internal-combustion engines in the setting up gear of which the screw is better than the lever. In the driving of a rubber machine for

use on plantations, where the operatives are natives and somewhat careless, the friction clutch is very necessary, and it can be quickly thrown out of gear in case of accidents.

The speed at which the clutch is to run is also an important point to consider. In that type of clutch in which the segments are loose the centrifugal action of these segments always tend to force them outwards, making them more difficult to throw out of gear if of the internal type, and more difficult to engage if of the external type. Those in which the centre is all in one piece, and forced out against the spring of the metal, are not affected by centrifugal force to the same extent. Plate type clutches are very little affected by centrifugal action.

The balance of a clutch is also of the greatest importance, as it is rapidly affected by any want of balance, if the speed reaches a point at which it becomes operative. It should, however, be properly balanced for any speed. The cone having no moving parts is undoubtedly the easiest to balance and keep in balance, and would be most used if it were not for its other inherent defects. If the speed is moderate, internal segment clutches, where made of sufficient excess of driving power, have run for periods of over 20 years without renewal, and where they were being constantly thrown in and out of gear. Another point which sometimes affects the use of clutches is the overall space required, which is more than that required by fast and loose pulleys. This is not always of moment, but there very often arise positions where it is important.

In the consideration of clutches as against fast and loose pulleys the question of cost should be looked into. That a belt used over fast and loose pulleys will wear away much faster than one which operates through a clutch is well known, but a clutch is more costly than pulleys, and we have to decide which will be the better. A clutch enables drives to be made by ropes or chains, which would be impracticable without the use of a clutch. Most tool-makers in the States use clutches on their countershafts, while English makers generally prefer fast and loose pulleys. The author has, in his own works, both sorts running, and although the clutch operates more quickly than fast and loose pulleys, the men do not at all agree as to which they like best. The clutch takes on the whole more power to operate.

Clutches require upkeep like any other machine, and whethere this cost is high or low depends on whether the margin of power is sufficient or not. If there is a good margin, there will be no trouble; if you have only just enough or just under, then trouble is your constant companion. People who buy clutches without considering the circumstances, or are determined solely by the price, often regret their choice, as in a good many lists the powers of the clutches are not understated, but designed to give a very favourable and even rosy hue to the figures.

Something can be said for the simplicity of magnetic clutches and freedom from mechanical movement, but you have to set against these the contacts, switches, cables, and other connections; anybody who has used these and handed them over to the care of some men know that they can equal anything in the way of pins and levers for trouble; also, the constant expense, without taking into account the initial cost, that accrues from the use of magnetic clutches is of moment—for instance, a charge of only ½d. per hour for current is to be looked at, at the end of a year, and is the interest on the price of a very large clutch.

A mechanical setting up gear takes nothing when set up, or, at least, only a small amount for wear and tear. Clutches should be depreciated at a greater rate than ordinary machine tools; they are often difficult to get at, and get attention only when they won't work.

The ideal friction clutch should be a combination of a friction drive and a positive drive. That is, a friction arrangement should be used for starting up, when that is in gear a positive drive should come in operation by which all driving is taken off the frictional portion. The clutch, however, should be able to be thrown out of gear with the same ease that a friction drive can be, and should have all running parts with ample clearance when running out of gear. A little consideration will show that while it may not be impossible it will be very difficult to attain for this reason. When the positive portion of the drive is thrown into gear, it will be this portion that will be doing the work, and when that is so, to throw this part out of gear creates the same difficulty that there is with a claw coupling—that is, the difficulty of quickly releasing it while under the pressure of the drive. Also it should always be in perfect balance, no projecting parts, lubricated so as not to give trouble, and free from complications.

Some years ago a clutch was put on the market which was a combination of a friction and positive drive, but the author has not heard of it for some time, and supposes that the difficulty with the release would be the probable cause of the trouble. The use of separate electric motors to each machine undoubtedly will affect the use of clutches, but even these are as capable of giving trouble as a clutch.

In order that the discussion on the paper may run in channels which, in the author's opinion, may lead to practical results, he suggests that the following points might receive the most attention: (1) The best means of lubrication of the clutch so that wear on the bushes may be kept down to the lowest point. (2) The question as to whether results justify the extra expenditure on clutches without a moving belt as against fast and loose pulleys with a moving belt. (3) What is the reason that British tool-makers stick to the fast and loose pulleys as against the use of clutches on their machine countershafts? (4) Does the magnetic clutch, as far as experience goes, justify the expenditure on current necessary to keep it in action? (5) Are friction surfaces of the woven or similar type better than metal to metal surfaces?

The foregoing indicate a broad basis upon which opinions may be expressed, and if members will only give their own experiences, some solid good may accrue from the discussion which the author hopes will follow.

*(Concluded.)*

## THE INTERNAL-COMBUSTION ENGINE.

By Dugald Clerk, D.Sc., F.R.S., M.Inst.C.E.

*(Continued from page 136.)*

In 1909 France had 46,000 motor-cars in use of an average of about 13 H.P., or a total of 598,000 H.P.

The power of stationary combustion engines in France is not available, but the four countries show a total of at least $5\frac{3}{4}$ millions in 1909.

This figure does not include oil and petrol engines used for marine purposes, which probably brings the total up to six millions.

In 1909, then, we find at least six million horse power of gas, oil, and petrol engines in the world a truly great development since 1876.

In the year 1909 America led the world in the power of such engines at work, Great Britain came second, and France and Germany were nearly equal with the third place; and although great expansion has taken place in all these countries, Germany still retains the same relative position America and England still lead.

In addition to internal combustion, all these engines have another feature in common—all compress the working fluid before combustion; some compress an inflammable mixture and fire the compressed mixture, producing a mild explosion with a strictly limited possible rise of pressure; some compress air alone and then mix at the temperature of compression the inflammable gas or vapour and ignite as before; and some compress the air charge so highly that on the injection of oil fuel in a state of very fine spray the heat of compression causes the ignition of the spray as it enters the cylinder—such engines do not produce an explosion; the pressure within the cylinder never exceeds the pressure of compression or the pressure of the compressed air sometimes used to pulverise or disperse the liquid oil.

The engines operated by explosion are called constant-volume engines, and those actuated by expansion, due to flame, constant pressure engines. Constant volume and constant pressure define the thermodynamic characteristics of the engines, but the mechanical cycle adopted to carry out in practice the necessary charging, compressing, igniting, expanding, and exhausting operations are varied. Two mechanical cycles are in general use: in one the motor piston and cylinder alternately act as pump and motor, so that four single strokes are necessary respectively for charging, compressing, expanding after igniting, and exhausting; in the other, these operations are performed in two single strokes of a piston; air or the charge, however, has to be pumped and lightly compressed by a separate lighter piston or by the front of the motor piston. All existing gas, oil and petrol engines, whether light or heavy, operate according to one of these cycles—the majority of engines in accordance with the four-stroke system.

This feature of compression before ignition is necessary in order to provide an economical engine expanding the gases of explosion in the most favourable manner and at the same time producing large power for small bulk. This mode of operation was the invention of an English engineer so far back as 1838. It will be found described in Wm. Barnett's Patent, No. 7615 of 1838, where he gives full particulars of a double-acting internal-combustion engine having separate air and gas pumps, which supply a charge under light pressure to a motor cylinder, in which there acts a piston overrunning a large port in the middle of the stroke. The charge displaces the products of the previous explosion, and is compressed by the return of the piston into a combustion space left at the end of the cylinder. Barnett had fully realised the advantages of compression before ignition, and proposed in accurate detail an engine closely resembling modern two-stroke engines. He was the originator of both the compression idea in its present form and the two-stroke cycle of operation.

The first German engineer to appreciate the advantages of compression was Gustav Schmidt, but he did this 23 years later than Barnett, in a paper read before the Society of German Engineers in 1861. Schmidt states, criticising the Lenoir non-compression engine: "The results would be far more favourable if compression pumps, worked from the engine, compressed the cold air and cold gas to three atmospheres before entrance into the cylinder; by this a great expansion and transformation of heat is possible."

Million, a clever Frenchman, in his Patent No. 1840 of 1861, shows that he had exceedingly clear ideas of the advantage of compression; he evidently considers himself as first to propose its use in a gas engine, apparently unaware of the existence of Barnett's engine which I have just described. He claims the exclusive right to use compression in the most emphatic language. One engine described is exactly what Schmidt asked for. Separate pumps compress the air and gas into a reservoir, from which the movement of the motor piston, during a portion of the stroke, withdraws its charge under compression. Ignition is accomplished by the electric spark, and the piston moves forward under the high pressure produced.

He also describes a compression engine in which the motive cylinder is made longer than necessary, in order that the piston shall always leave between it and the end of the cylinder a space such as one-fourth or one-third of the volume generated by the motor piston. Here he resembles Barnett and the modern internal-combustion engines.

M. Alph. Beau de Rochas, a brilliant Frenchman, in a remarkably clever pamphlet published in Paris in 1862, discusses the conditions of economy in gas engines using compression with reference to volume of hot gas and cooling surface to which they are exposed.

He states that four conditions are necessary in order to obtain the maximum economy in a compression explosion engine:—

1. The greatest possible cylinder volume with least possible cooling surface;
2. The greatest possible rapidity of expansion;
3. The greatest possible expansion; and
4. The greatest possible pressure at the commencement of the expansion.

He therefore reasons that a large cylinder is necessary, and the time of exposure to cooling should be as short as possible and piston speed high.

He considers that the sole arrangement capable of meet- the conditions is a single-cylinder engine having the following series of operations:—

1. Suction during an entire out-stroke of the piston;
2. Compression during the following in-stroke;
3. Ignition at the dead point and expansion during the third stroke;
4. Forcing out of the burned gases on the fourth and last return stroke.

The ignition he proposes to accomplish by increase of temperature due to compression. This he expected to do by compressing to one-fourth of the original volume. He also proposes a double-acting engine of the same type with piston rod and stuffing-box.

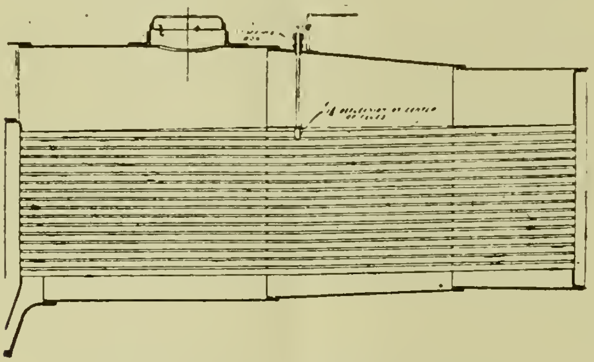
Beau de Rochas' proposal had to wait for fourteen years before it was put into successful practice. The late Dr. N. A. Otto, of Cologne, succeeded in overcoming the practical difficulties in the year 1876, when he produced the first commercially successful gas engine utilising the idea of compression before ignition, first proposed 38 years before by the English engineer Barnett, applied by the means of the cycle of operations due to Beau de Rochas. The modern four-stroke engine was thus the outcome of the English, French, and German brain. The world, however, remains deeply indebted to the late Dr. Otto, whose ability and pertinacity, applied at the crucial time, produced an engine which marks an epoch in the advance of internal-combustion motors. Dr. Otto deserved his success; he had fought long and hardly for it. He was born at Holzhausen, in Nassau in 1832; he began his work on gas engines in 1854 at 22 years of age; attained his first success—the Otto and Langen engine already referred to—in 1866; and made his epoch-making advance in 1876. He applied his whole life to the study and development of the gas engine, and died in the year 1891 at the age of 59, after 37 years devoted to the problems of internal combustion.

*(To be continued.)*

## BOILER EXPANSION EXPERIMENTS

THE results of tests made on the New York Central Railroad system to determine relative movements of locomotive firebox sheets and tubes under working conditions are given by D. R. Macbain in the October issue of the "Railway Mechanical Engineer." The experiments showed that the expansion of the outer sheets was greater in every case than that of the inner sheets, which would seem to account for the breakage of the back head and throat sheets along the outer row of staybolts, also for the vertical cracks in the side sheets as well as the cracks extending from the arch tube holes. It was also found by means of a needle connected with the inner throat sheet and passing through the outer throat sheet that the inner tube sheet moved outward $^{3}/_{32}$ in. when the fire was started, and before the circulation was fully established, and later, when steam pressure began to rise, backward about $^{1}/_{16}$ in. The first movement throws some light on the cause of the side sheet cropping out along the fire line, as it does sometimes.

Another source of trouble was found with the breakage of staybolts in some of the wide firebox engines. It was believed previously that the cause of these bolts breaking was the same as that which was responsible for the leaky side sheet seams, and, further, that the elimination of

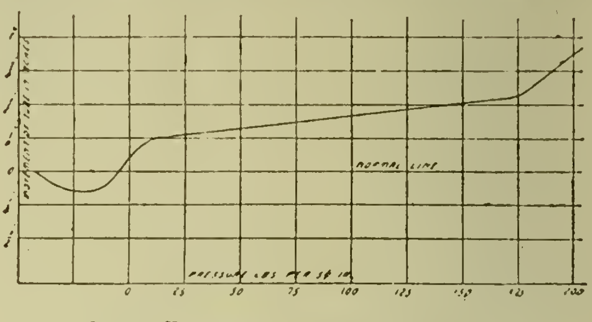


BOILER EXPANSION EXPERIMENTS.—FIG. 1.

excessive staybolt breakage would result in a cure for these leaky seams. With rigid bolts it was quite common to find anywhere from three to five or more bolts broken. An experiment was therefore tried on an Atlantic-type engine while it was undergoing repairs. A heavy template was fitted from the side of the boiler when the boiler was cold, and was firmly clamped at its centre to the boiler. The fit was very carefully made. The engine was then fired up and the effect of heating up the boiler to the point where 200 lbs. of steam was obtained caused the wrapper sheet to bulge out so that there was $^{3}/_{32}$-in. opening between the template and the wrapper sheet at both ends of the template. This apparently explains the cause of the breakage of the staybolts.

In order to determine whether this distortion of the boiler was caused by the pressure or the heat, the template was carefully refitted and a pressure of 225 lbs. of cold water put on the boiler. The template retained its shape, which proved conclusively that the distortion was due to the temperature and not to the pressure. The application of three rows of flexible staybolts stopped the trouble and cured the leaky seams.

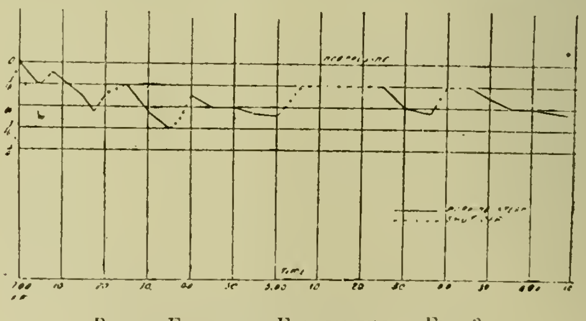
Experiments were also made to determine why the back and front tube sheets become deflected or distorted. It was believed that while the boiler was working and had a hot fire, the expansion in the boiler proper, that is, between the tube sheets, was greater than in the tubes. An experimental set of tubes was installed in a large Pacific-type locomotive, each tube being given a drop of $^{15}/_{16}$ in. at the centre, but fastened at each end. A rod was fastened to one of the top tubes at the centre and extended up through a stuffing-box in the boiler shell, as shown in Fig. 1, the outer end being attached to a recording device which would register the movements of the



BOILER EXPANSION EXPERIMENTS.—FIG. 2.

tube. Fig. 2 shows the result of a standing test from the time the fire was started until 200 lbs. pressure in the boiler was obtained. Almost immediately after the fire was started the tube deflected still more until it had reached $\frac{1}{8}$ in. It remained in this position for a short time and then it rose and was about $\frac{1}{8}$ in. above its normal position when the steam pressure began to rise. It rose gradually until 175 lbs. pressure, and then rose rather abruptly. This rapid rise may have been due to the needle sticking a little in the stuffing-box. Fig. 3 is the record of another test, namely, on a road trip from West Albany to Rotterdam Junction. The solid lines are readings taken when the throttle was open, and the dotted lines with the throttle closed and the engine drifting. It is seen that immediately upon starting the tubes began to deflect, and rose when the engine was not working steam.

An investigation was also made to determine the direction and extent of expansion in a tube sheet resulting from prossering a set of new tubes. A circle of as large diameter as possible was described on the tube sheet, and after the tubes had been set it was found that this circle had increased or had widened out $^{1}/_{32}$ in. at the side and bottom and $^{3}/_{32}$ in. at the top. It has been the experience there that the 3-in. radius for the tube sheet flange will give better results than the 2 in.



BOILER EXPANSION EXPERIMENTS.—FIG. 3.

Data on the relative movements of the back tube sheet to the throat sheet are given for the time from the moment the boiler is heated up and raised to 200 lbs. pressure and released back to zero pressure. It was found that it is necessary to allow some freedom to the sheets longitudinally in order to avoid excessive strains being set up.

# HARDNESS TEST FOR HARDENED JOURNALS AND PINS.*

The Committee was appointed in 1914 "to report on a Hardness Test for Hardened Journals and Pins," and its membership now stands as follows: W. Cawthorne Unwin, LL.D., F.R.S., Chairman: Archibald Barr, LL.D., D.Sc.; Sir Robert A. Hadfield, D.Sc., D.Met., F.R.S.; Captain H. Riall Sankey, C.B., R.E., ret.; T. E. Stanton, D.Sc., F.R.S.; and A. E. H. Tutton, D.Sc., F.R.S.

The Committee originated in some letters from the Mirrlees Watson Co. to the late Mr. Leslie Robertson, the Secretary of the Engineering Standards Committee, who suggested that the question was one suitable for investigation by a Research Committee of the Institution. The Mirrlees Watson Co. wrote that "they had found difficulty in fixing a standard of hardness—for instance, in bearings where shafts or pins work at high speeds under heavy loads."

The Committee has held several meetings, and has corresponded with some manufacturers and others who were likely to have adopted some method of testing hardness.

A memorandum was prepared by the Chairman (Appendix I.) on such methods of testing hardness as were known to have been used. It appeared that for ductile materials an indentation test (Brinell or Shore scleroscope) was largely used, and was found to give useful information. Both these methods appeared less satisfactory for very hard materials, such as those indicated in the reference to the Committee. Further, it had been shown by Mr. Saniter that resistance to wear, as in the case of a pin or journal, did not directly depend on the hardness as measured by the indentation test.

The question of the property of materials which ensures resistance to wear on rolling or sliding surfaces appeared to be strictly within the reference to the Committee. It was therefore decided that experiments on resistance to wear, and especially in the case of dry surfaces, should be made at the National Physical Laboratory. Dr. Stanton designed more than one form of testing-machine for this purpose, and carried out the researches of which an account is given in the paper which forms part of this report. Brinell and scleroscope tests were made at the same time, so that a comparison could be made between the resistance to wear and the ordinary indentation measure of hardness. The form of testing-machine designed by Dr. Stanton, in which there is a definite sliding between dry revolving surfaces, seems likely to be of considerable value in solving the precise question put forward by the Mirrlees Watson Co.

The Committee is much indebted to Sir Robert Hadfield for supplying the materials on which Dr. Stanton's tests were made; also to Mr. R. G. Batson, of the National Physical Laboratory, to whose care in making the tests the success of the research was due. The Research Council of the Board of Education have made a grant of £100 supplementing that from the Institution.

Report on Experiments made at the National Physical Laboratory by Dr. T. E. Stanton and Mr. R. G. Batson:—

A description of the nature of some of the better known of the various tests which have been devised for obtaining the relative resistance of materials to surface deformation, to all of which the term "hardness tests" is sometimes loosely applied, is given in Appendix I. by the Chairman of the Committee. A preliminary examination of these methods shows that each of them falls into one or the other of two distinct categories. These are:—

(1) Abrasion or scratch tests, in which particles of the material whose "hardness" is to be determined are torn away from its surface by sliding contact with some other substance, whose corresponding resistance is so high that its surface remains unimpaired by the action.

(2) Indentation tests, in which the surface of the material under test is permanently distorted by the pressure of a hard steel ball, cone, or knife edge.

If each of these methods were a measure of the same definite property of the material which is as characteristic of it as, say, its elasticity, it is evident that the ratio of the results of any two of the methods would be the same for every material tested. Comparisons between the results of these various tests have formed the subject of several researches which have been published during recent years. The general conclusions, as summarised by Professor Turner in his paper on "Hardness," read at the Iron and Steel Institute meeting of 1909, appear to be that, although an approximate agreement may seem to exist between the various methods when applied to the case of relatively pure metals in their cast or normal state, yet when the resistance to deformation is due to tempering or to mechanical treatment no comparison is possible.

That this should be so would seem to follow from the consideration that the resistance which any so-called hardness test is supposed to measure is that which the body under test exerts against a complex distribution of stress over its surface which has partially deformed or disintegrated it, and it is evident that its value will depend, not on the stress constants of the material such as its yield point, ultimate tensile and shear stresses, but on intermediate stresses, the precise nature and distribution of which are unknown and whose ratio to the stress constants may not be constant for the same method. If, therefore, such resistance, without qualification, be defined as the hardness of the material in its broadest sense, it is clear that, as pointed out in the memorandum to the Committee communicated from the members of Sir Robert Hadfield's laboratory (Appendix II.), hardness is no more a definite quality of a material than is the strength of a piece of steel of definite dimensions. In the latter case, if the nature, amount and distribution of the stress are known, its resistance has a definite value which can be calculated. The only difference between this case and that of the hardness test is that, since in the determination of hardness there is no possibility of estimating the stress magnitude and distribution, we are driven more to direct observation of the consequences of such distribution than to a calculation of these consequences from the known characteristics of the material. Mechanical phenomena of this kind are familiar to engineers under other aspects, such as in the cases of the resistance of ships and aircraft to propulsion; but whereas in these latter cases the problem is to determine the resultant force exerted by the unknown pressure distribution, in the present case, as in the corresponding one of the resistance of materials to impact, the unknown quantity is the ultimate resistance of the material to the unknown stress distribution. In all the cases, however, the practical method of solution is an experimental one, and consists of setting up a similar, or nearly similar, state of stress on a specimen of the material whose behaviour is under investigation and noting its effects.

It cannot, however, be said that modern engineering practice is entirely in accordance with the views laid down above, although the development of what are called

* Report of the Hardness Tests Research Committee of the Institution of Mechanical Engineers.

"wear" tests in recent years is an indication that it is coming to be recognised that the results obtained in the relatively simple cases of stress distribution in the indentation test or the scratch test are not applicable to those in which the action is a combination of the two effects of normal pressure and sliding. For example, there are wear tests for measuring the particular form of disintegration which takes place on the surface of steel rails due to the rolling abrasion of heavily-loaded wheels. The characteristics of this kind of wear are the extremely small amount of the relative movement between rail and wheel and the high intensity of the compressive stress at the line of contact. On the other hand, there are wear tests of lubricated surfaces in which the pressure is relatively small and the rate of slipping large.

Notwithstanding this development, there seems to be no doubt that with many engineers it is still customary to regard the hardness as determined by an indentation test as a definite property of material, and as a measure of the resistance of the material to wear of any possible kind that is likely to be experienced in its use. In the face of this practice it appears to be of importance to determine under what circumstances the custom here referred to may be flagrantly misleading, or merely a rough guide, which is better than no guide at all. As pointed out in Sir Robert Hadfield's memorandum, the use of an indentation test in the case of manganese steel rails is highly misleading: but, on the other hand, in Mr. Saniter's wear tests of ordinary carbon steels the correspondence between the results of the indentation and wear tests was fairly close.

On looking into the available evidence it appeared that the ground hitherto covered was not sufficient to enable any broad generalisation to be attempted, and the committee therefore decided, as a preliminary research, that a comparison should be made of the results of both hardness tests and wear tests of materials whose composition and thermal and mechanical conditions of production extended over a wide range. A series of experiments for this purpose were accordingly undertaken at the National Physical Laboratory.

*(To be continued.)*

## ENGINEERING INDUSTRIES AFTER THE WAR.

A meeting of representatives of the Scottish iron, steel, engineering, shipbuilding, and allied industries was held in Glasgow in August last, when a "preliminary" Committee was appointed to consider and report upon certain questions. This Committee has now issued its report, in which it is said that the following general points are of outstanding importance in considering the question before them:—

1. (*a*) It is assumed that the Government will take a more active part in the future in encouraging, by every means in its power, the development of the industries of this country.

(*b*) After consideration of the various aspects of the probable post-war conditions, the Committee is of opinion that the factor that will have the greatest effect on the prosperity of the country in general, and the industries in which we are interested in particular, and that will overshadow all other factors, is the question of increased production. Unless the capacity of efficiently equipped industrial concerns is utilised to the fullest extent, and the largest available output is attained, all other measures of assistance or regulation will be of secondary value in attaining the expansion and prosperity of our industries and the comfort and well-being of those employed in them.

(*c*) Increased productivity can only be attained by a more cordial co-operation between employers and employees than has existed in the past; by efficient equipment and organisation on the one hand, and, on the other, by the abolition of all restrictions and practices limiting output.

The existing policy of limiting output, and of refusing in many cases any system of payment by results so that employment may last longer or that more men may be employed, is agreed to be economically unsound and inimical to the best interests of the Empire.

(*d*) In order to secure the foregoing, it is essential that in the remuneration of employees some form of payment by results should be adopted wherever possible, with basis rates, compatible with the productive effect of labour, fixed on such a scale as will ensure for all willing workers a good and comfortable standard of living. Once these basis rates have been equitably fixed and established, an increase in earnings, due to increased results, should be encouraged in every way; and workmen should have the security given them, that any enhancement of their earnings following increased production, will not be made a ground for rate-cutting, as the whole success of the system must inevitably rest upon mutual confidence.

(*e*) In view of the foregoing considerations, any organisation which may be instituted should be prepared to co-operate with labour, as without such co-operation and assistance the desired result will be difficult of attainment.

(*f*) An increased supply produced under the improved conditions outlined above may be confidently expected to create a correspondingly increased demand, and that quite apart from the increased demand which it is widely anticipated will arise after the war. At the same time, attention and efforts must be directed to maintaining and extending existing markets and securing additional markets.

2. Supplementing these general considerations, the following is an indication, not necessarily exhaustive, of the objects that any organisation which may be instituted should have in view, viz.:—

(*a*) To direct the attention of the Government and its Departments, for their information and guidance, to matters requiring consideration and action in the interests of the industries concerned, and to initiate and review legislative proposals on commercial, industrial, and economic matters.

(*b*) To deal with questions affecting the labour conditions and internal organisation and disabilities of the industries concerned, with a view to securing increased efficiency from an Imperial and national point of view.

(*c*) To educate and inform public opinion in accordance with its recommendations and findings.

3. As examples of the questions under these headings which might have to be dealt with, the following have been mentioned, but it is to be clearly understood that the preliminary Committee express no opinion on the merits of any particular point. The examples are only given as illustrating in a general way the questions which might arise for consideration, viz.:—

(*a*) Consideration of all conditions affecting trade and industry proposed to be embodied in the terms of peace, or in any treaty.

(*b*) The effect on industry of regulation of imports and exports by means of tariffs, subsidies, or prohibitions.

(*c*) The effect of existing banking methods on industrial enterprise.

(*d*) The question of facilities and rates for transport by rail, road, or water.

(*e*) The safeguarding of existing and the securing of additional markets.

(*f*) The establishment of efficient consular services in relation to foreign trade.

(*g*) Questions relating to sickness and unemployment insurance and pensions.

(*h*) Means of giving workpeople a continuing interest in the prosperity of the industry in which they are employed.

(*i*) Remuneration of workpeople according to output by piecework, premium bonus, or other system of remuneration, and the grading of labour according to skill and ability.

(*k*) Rates of wages, working hours and demarcation of work between skilled and unskilled workpeople, between men and women, and between different skilled trades.

(*l*) To consider present promiscuous methods and times of making general advances or reductions of wages.

(*m*) The apprenticeship question—how affected by the experiences of the war, and from all points of view.

(*n*) Questions affecting the employment of women workers.

(*o*) Social amenities of workshops, and the well-being of young people engaged in industries.

(*p*) The effect on the industrial efficiency of the country of existing or pre-war restrictions of freedom of management and control.

(*q*) The provision of machinery for avoiding strikes and lockouts, and for settling questions which arise between employers and employed.

(*r*) The review of the procedure of employers' associations, trade unions, or other combinations of employers, or workpeople where such tends to interfere with the liberty of the subject without national benefit.

(*s*) Questions of scientific and technical education.

(*t*) Industrial research and experimental investigation.

(*u*) Whether it is desirable in view of the grave disadvantages which have arisen in the past from the failure of individual employers and individual workmen to carry out agreements made on their behalf by their accredited representatives, that some method of making the associations of employers and employees responsible for their members should be adopted.

4. The questions to be dealt with fall into two divisions:

(*a*) Such questions affecting labour as are best dealt with directly between specific classes of employers and their employees.

(*b*) Questions in which labour is only indirectly interested, and which can be dealt with separately by employers.

5. Questions which fall under the first category have in the past been dealt with between employers' associations and trade unions with a fair measure of success. In view of the undesirability of multiplying organisations, and of the value of the existing staffs with their experience, knowledge, and records, it appears most natural and practicable to take advantage of existing organisations and improve and extend them to deal with such questions.

With this object, existing employers' organisations should include all employers engaged in the industry and within the district.

Where, in any district or industry, no association exists an association should be formed.

6. As regards questions which fall under the second category, it is considered that employers who belong to associations with constitutions which enable them to deal with such questions are (subject to the proposal dealt with later) already provided for. In other cases either the existing associations should extend their constitutions to cover such questions or employers should join some existing association (for which they are eligible) which covers the ground, or, as an alternative only to be adopted in the last resort, a new association should be formed with an appropriate constitution. In the foregoing arrangement it is felt that associations should neither as regards the industries or areas covered be so large as to be unwieldy nor as small as to be parochial.

7. In order to co-ordinate the activities of the various organisations, to obtain due recognition of properly-constituted employers' and employees' associations, to confirm in or endorse voluntary agreements between employers and employees, and, where desirable, to give legal effect to the recommendations of these associations, it is considered that some central organisation is necessary which should have Governmental recognition to give it weight and authority.

8. It is suggested that the central organisation should take the form of a National Advisory Council of Industry consisting of two bodies, viz., representatives of employers and representatives of employees, who would meet either separately or together, as the nature of the questions to be considered might require—the joint meeting being always (and the meetings of the separate bodies as required) presided over by the Minister of Industry mentioned hereafter. The employers' representatives should be elected by the various employers' organisations, in number and proportions to be determined, with possibly additional employers' representatives nominated directly by the Government. The employers' representation should be similarly determined. Government departments might also be represented at the joint or separate meetings, or might, if thought desirable, constitute a separate body available for joint meetings. This Governmental representation would safeguard the interests of the State and the community as against the personal interests of the employers and the employees.

9. In actual practice it might be found desirable that the National Advisory Council should be chosen from amongst local councils formed for large industrial areas; for example, Scotland could form one such area. As some industries are federated over the whole country, and others are only associated locally, this point requires careful consideration. In any case, it appears desirable that local associations should federate with other associations in the same industry for certain purposes at least, over as large an area as possible.

10. It is suggested that a Minister of Industry should be appointed, and in this connection the appointment of an individual retaining a connection with either the employers' or the employees' side of industry is undesirable, as is the appointment of an individual having only a political or a legal qualification. It is suggested that while a Minister of Industry should not be a permanent official, neither should his appointment nor retiral be dependent on a change of Government. Such a Minister would form the connecting link between the Government and the central organisation described in the eighth paragraph.

The Preliminary Committee also suggests that a Temporary Committee be appointed, representative of the industries concerned in Scotland, to take steps to put into practical effect the general principles enunciated.

## POWER FROM A VOLCANO IN TUSCANY.

This remarkable installation, giving power by the generation of natural steam, is described by Professor Luiggi, D.Sc., M.Inst.C.E., in "Engineering," and is briefly as follows: As is well known, in Central Tuscany, near Volterra, there are numerous cracks in the ground from which powerful jets of very hot steam spout high in the air with great violence and constancy, bringing up boric acid, which is very valuable, and other mineral substances of less importance. These powerful jets of superheated steam are called *soffioni*—the "blowers"—and have been utilised for many years in the production of boric acid and borax, and occasionally for warming the houses in the near-by village of Larderello. The larger proportion of the steam, however, is lost, having no local application, and with it is lost its very valuable heat. Prince Ginori-Conti, the President of the "Società Boracifera de Larderello," tried to get a more ample supply than is afforded by the borax works, by boring holes in the ground, lined with iron pipes, driven down to the very source of the steam, which is under a hard stratum of rock about 300 ft. to 500 ft. below the surface. These bore-holes vary from 12 in. to 20 in. in diameter, and give forth steam with a pressure from 2 to 3—and, exceptionally, up to 5—atmospheres, and at temperatures varying from 150 deg. Cen. to 190 deg. Cen. For several years these jets have not diminished in their capacity, nor does a new boring seem to interfere with the preceding ones, provided the distance from one to another is not less than 50 ft. Acting on the advice of the Tosi Works, of Legnano, specialists in steam turbines and alternating electric generators, he ordered three groups of condensing turbo-electric engines, each of 3,000 kw., working with superheated steam at 1½ atmospheres, generated in specially constructed multitubular boilers, the latter arranged vertically and with aluminium tubes, both for better utilisation of the heat and better resistance to the corrosive action of the natural steam from the *soffioni*. This steam, it is worth while to repeat, is used instead of combustible; it loses part of its heat in the boiler, reducing its temperature from 180 deg. Cen. to about 120 deg. Cen., and is then utilised for the borax industries. The steam thus generated in the boilers and used for the turbines is ordinary water steam, which, on its way to the turbine, passes along aluminium pipes heated outside by a current of superheated natural steam, at 180 deg. Cen., and thus gets in its turn superheated to about 150 deg. Cen. After passing through the turbine this steam is discharged into a surface condenser, the circulating water of which is in its turn cooled in an ordinary cooling tower. The condensed steam from the turbines is, of course, pumped back into the boilers, and thus no natural steam ever comes in contact with the turbine. The tri-phase electric current is generated at 4,500 volts and 50 periods per second, raised up through an oil transformer to 36,000 volts, and sent along aerial conductors to Florence, Leghorn, Volterra, Grosseto, and many smaller towns of Tuscany, to be principally used as motive power for munition works during daytime and partly for lighting purposes at night. One of the 3,000-kw. units has been at work since January, 1916, the second since April, and the third has just been started. So far, the first two groups have worked quite successfully, and have been a great boon to the industries of Tuscany, greatly crippled by the scarcity and high price of coal. This very successful harnessing of volcanic heat to an electric power-house can be increased practically to hundreds of thousands of horse power, as the region of the *soffioni* extends for many square miles around Lardello. Similar installations to the above are contemplated near Naples, where there is another large area giving out steam.

## FREQUENCY.

By F. Ashton.

### The Question of Standardising Frequencies.

When engineers began to build electric-lighting stations some endeavour ought to have been made to standardise frequencies, for whilst there is, of course, no difficulty in running stations at different frequencies so long as they work independently, when it comes to linking up considerable inconvenience is involved. No method has been invented or is likely to be invented which will enable frequencies to be changed, on a large commercial scale, without the use of some form of running machine. The frequency of an alternator is found by multiplying the number of pairs of poles by the revolutions per minute, and the cycles per second are obtained by dividing this quantity by 60. Evidently an appreciable change in the frequency of a station can only be made by re-equipping it with a new machine, but stations of different frequencies can, of course, be coupled up through motor generators.

### Cycles per Second.

When alternators were built solely for lighting purposes the frequencies were in the neighbourhood of 100 cycles per second, but within recent years electricity has been put to many other uses and much lower frequencies have had to be adopted. Twenty-five cycle current is employed very largely on all electric-traction systems, irrespective of the kind of current than is supplied to the track. The reason for this, in the case of continuous-current systems with polyphase transmission, is that the construction of rotary converters for frequnecies above 25 cycles presented in the early days very considerable difficulties, and in operation their behaviour left much to be desired. Moreover, with reciprocating engines parallel running is less satisfactory at, say, 60 cycles than at 25 cycles. Reciprocating engines impress on the system cyclic irregularities which are apt under certain conditions to lead to serious hunting. It is not to be wondered at, therefore, that since turbines with a perfectly even turning moment have replaced reciprocating engines in most large generating stations hunting troubles have greatly diminished. Owing partly to the introduction to these prime movers and partly to improvements in the design of rotary converters, 60-cycle three-phase current can now be efficiently converted into continuous current. Stable running in the early days of 60-cycle rotaries was not always easy to acquire, and when short-circuits occurred on the line bad flashing over occurred at the brushes, with the result that it became customary to employ rotary converters only on the lower frequency circuits; that is to say, on circuits supplying currents at 25 or 33 cycles. Motor generators or motor converters were always adopted on the higher frequency circuits. New traction stations are now almost invariably equipped with 25 or 33-cycle machines, so that conversion with the aid of rotary converters does not involve any difficulty at all. There are, however, a fair number of 60-cycle rotary converters in service, especially in America, where the opinion is now held by a fair number of engineers that 60-cycle rotaries are now every bit as good as 25-cycle machines.

### Diversity of Frequencies.

If 25 and 60 cycles were the only two frequencies in use—and there appears to be no very logical reason why this should not be the case—electrical designers would be saved a great deal of work, for a motor designed for one frequency cannot be used on a circuit working at another frequency. What applies to motors applies also to some extent to transformers. Both in America and this country stations are working at widely different frequencies, which is a very unfortunate state of affairs. There is some excuse for variations in this connection in the case of the earliest stations, which were built in the first place solely for lighting, but why all modern tractions stations have not exactly the same frequency is difficult to understand. The Underground and Metropolitan generating station at Chelsea, for instance, supplies 33-cycle current, while the London County Council tramway station and the London and South-Western and London and North-Western Railways' generating stations supply 25-cycle current. Obviously, the former station cannot be connected with the others without the aid of frequency-changing machinery. It is interesting, quite apart from any question of inter-connecting, to consider the influence frequency has upon electrical apparatus and machines. Take induction motors for example. On comparing motors of the same capacities and speeds, it will be found that on an average 25-cycle machines weigh about 15 per cent more than 60-cycle motors. In the small sizes the difference in cost is not very appreciable, but as the size increases, the 25-cycle motors become more expensive than those that work on 60-cycle circuits. When very low speeds are required 25-cycle current is, of course, advantageous, but even if 25-cycle induction be wound for only two poles, which is rarely the case, its speed cannot exceed 1,500 revolutions per minute. A two-pole 60-cycle motor, on the other hand, would run at practically 3,600 revolutions per minute. Except in the case of very small motors, however, a two-pole construction involves difficulties. Since the flux per pole in a two-speed machine must be twice as great as that in a four-pole motor of corresponding output the section of iron behind the slots must in the former case be twice as great as that in the 60-cycle machine. Further, the end connections are long and the winding difficult, with the result that the cost of manufacture is considerably increased.

### Motors and Frequencies.

There is no difficulty in building induction motors with four or more poles for either 25 or 60-cycle circuits; where the manufacturers' difficulties come in is in the direction of providing motors to meet all the frequencies and voltages now in vogue. American manufacturers are at the present time compelled to develop a line of motors for 25, 33, 40, 50, and 60 cycles. Each size of motor has to be made for about ten different voltages and sometimes for two or more speeds. Moreover, each size of motor at each periodicity and each voltage has to be made in the totally enclosed, semi-enclosed, and in horizontal and vertical types. All these variations in design involve a great deal of work, which is reflected in the cost of all motors produced. So far as America is concerned, there appears to be a tendency to make 60 and 25-cycles standard frequencies; although, of course, the other frequencies at present in use will not be at all easy to eliminate. Frequency also has a marked influence on the cost of generators, especially of those coupled to steam turbines. The steam turbine is essentially a high-speed machine, and since a 25-cycle alternator cannot run above 1,500 revolutions per minute, it will readily be seen that 25 cycles may easily impose limitations upon designers which will appreciably increase the cost of generating sets. Turbo-alternators for a speed of 1,500 revolutions per minute, especially those having capacities of less than 10,000 kw., are more costly, less efficient, and require more floor space than 60-cycle alternators.

### Influence of Frequency on Transformers.

The influence of frequency on transformers is very marked. As the frequency decreases, the cost and weight increase, for the lower the frequency the larger the flux and the larger the number of turns for the same voltage. Owing, moreover, to the larger number of turns the regulation of the lower frequency transformers is not as a rule so good as that of transformers designed for higher frequency circuits. Transformers designed for one particular frequency can be and occasionally are used on circuits having higher frequencies. But if a transformer be used on a circuit having a frequency below that for which it is designed the large no-load current consequent upon the very high densities in the core gives rise to a low-power factor, and further, the core loss at the lower periodicity is in excess of that prevalent when the transformer is working under the condition for which it was designed. Of course, the lower frequency in itself reduced the core loss, but the decrease in this loss is more than off set by the increased loss occasioned by the higher flux density, and the net result is an increase in the core loss. For the lower periodicity circuits, therefore, manufacturers have to get out special designs. The output of the transformer is a function of the magnetic and current densities at which the iron and copper are working, the space factor, the area of the iron and copper, and the frequency at which the transformer is operating. With other things constant, the greater the densities at which the iron and copper are working the greater will be the output of the transformer and the greater the iron and copper losses. The limit to which densities may be increased is determined in the core by the saturation point of the iron and in the copper by the amount of heating. Frequency also influences the pressure drop in conductors, particularly iron and steel conductors. Quite apart from 60-cycle current being totally unsuited for single-phase traction motors, it cannot be used on single railways on account of the excessive impedance drop it produces in the rails. A Swiss Committee appointed some time ago to investigate the frequency question in connection with single-phase railways came to the conclusion that for this purpose 15-cycle current is preferable to 25-cycle current. Not only does the lower frequency reduce the rail drop, but it also leads to more satisfactory motors. Fifteen-cycle generating and transforming plant, however, is more expensive than 25-cycle plant.

Enough has been said to indicate that when once an electrical system has been designed and laid out for a given frequency it is not at all easy to alter that frequency, for even if the station were entirely equipped with new machines for generating current at a different frequency to that of the original machines, the motors and transformers on the mains would not adapt themselves to the new conditions. When coupling up existing alternating-current stations the frequencies must remain as they are. To couple up stations working at different frequencies use must be made of motor generators, the number of poles on the two sides of each set being such that when the motor is connected to one station working at a particular frequency and a generator to another station working at a different frequency the synchronous speed in each case will be the same; this condition being, of course, necessary, since the two machines constituting the motor generator are mechanically connected.

# ENGINE FOUNDATIONS.

By A. Vincent Clark.

## Foundation Materials.

Foundations for engines are usually made of concrete on account of its low cost, and because the materials for making it can be readily obtained. Also the materials are easily mixed, and can be readily shaped to the required dimensions. Concrete is particularly suitable for making foundations, as skilled labour is not required, and when completed the foundation is a solid mass, also it absorbs vibrations much more readily than a foundation built of brick or stone. In addition, when the foundation is being made, it conforms to any irregularity of the ground, so giving a perfect distribution of the load over the soil.

The materials used for making concrete are cement, sand, and crushed stone or gravel. The sand, termed the fine aggregate, and the gravel, termed the coarse aggregate, not only reduces the cost of the concrete, but also increases the strength, and the cement acts as a binder to hold the concrete together. Portland cement of any standard brand is reliable, but it is always advisable to buy cement from dealers who are familiar with it, in order to ensure that Portland cement is actually obtained. Fineness and weight combined indicate good quality, and the weight is approximately 110 lbs per bushel, but heaviness is frequently obtained by coarse grinding. Good cement is of a blue-grey colour, and quick-setting cement, which is rather brownish in colour, should be avoided, as it often turns out weak, and has too large a proportion of clay in its composition.

Sand, or gravel, when heaped up has innumerable small spaces between the various particles, and the amount of this space is usually given as a percentage of the total volume. It is readily seen that this percentage of voids in the fine and coarse aggregates is the basis for the proportioning of the materials when mixing a concrete. To obtain a dense, strong concrete the proportion of the fine and coarse aggregates and of the cement should be arranged so that the possibility of spaces is reduced to a minimum.

Sand which is hard, clean, and coarse should be used as the fine aggregate; with a sharp sand the percentage of voids is greater, so the concrete cannot be made as strong as with a sand with rounded grains. The sand must also be clean, otherwise the cement cannot adhere to it, so if necessary it should be washed with water. The sand should not be uniform in size, as a smaller quantity of cement is required if the sand is well graded from coarse to fine with the former predominating, but which should not be greater than $\frac{1}{4}$ in. in size.

The coarse aggregate used is crushed stone or gravel, and this should be hard, clean, and well graded in size. The hardness of this greatly affects the quality of the concrete, and the relative values of the different aggregates, when made of the following material is given in the order below:—Granite, gravel, marble, limestone, sandstone, slate, cinders. The stone should be cubical in structure, as then it packs more closely, also this should be clean in order to allow the cement to adhere, and a stone with a chalky surface cannot produce a really good concrete. Pieces smaller than $\frac{1}{4}$ in. in size should be screened out and used as sand, and the remainder should be well graded in sizes up to $1\frac{1}{4}$ in. Large pieces tend to separate from the mortar, but when large masses of concrete are being prepared they may be used, and sometimes quite large stones are dropped into the wet concrete in order to cheapen the foundation.

Only clean water should be used for mixing the concrete, and the water must be quite free from all vegetable matter, strong alkalis and acids. Generally the mixing of concrete is thought to be a very simple process, and the work is left to any class of labour. It must, however, be pointed out that to get a strong concrete great care should be taken in the mixing, and especially in the proportions used. If this is done, and ordinary care exercised, satisfactory and consistent results will be obtained.

The proportions of cement and fine and coarse aggregates are usually decided after an inspection of the soil upon which the foundation is being made, and the mixture most generally adopted is one part by volume of cement, two parts by volume of fine aggregate, and four parts by volume of coarse aggregate. When prepared in this proportion the weight of the finished concrete is approximately 140 lbs. per cubic foot.

The mixing of the materials should be done before any water is added, and the mixture should be turned over at least twice in its dry state. It can then be spread evenly on a water-tight platform, and mixed again until the mixture has the appearance of a uniform colour, then form a large crater in the centre for the reception of the water, into which the required amount of water is poured. To assist the absorption of the water the material should be turned slowly into the crater, then the mixture must be thoroughly mixed until all the particles are coated with the mortar. If more water is needed it should be added by a springling can, and it will be noticed that the mixture becomes more moist as the mixing progresses, indicating that the particles are being forced closer together. After this has been done the concrete is ready for placing in position.

The foundation should be prepared at once, and the concrete should be put on in layers, each layer being rammed in order to produce a dense mixture. It is preferable for the work of placing the concrete to be carried on continuously until the job is completed, but where this is not possible the old concrete should be well wetted before the new is added. Holes are usually left in the foundation block for receiving the foundation bolts, and these are formed by square wooden cases, around which the concrete is poured. The holes are large enough for receiving the plate at the end of the foundation bolt, and it is always better that these holes should be taper, being made larger at the bottom than at the top, so that the pull on the foundation bolts tends to wedge the grouting material with which these holes are afterwards filled more tightly to the foundation block. An alternative method sometimes adopted is to step the hole so that the bottom part where the foundation plate comes is larger than the upper part. When the concrete has hardened these wooden cases can be removed by splitting up one of the sides. Sometimes the foundation bolts and plates are put into position before pouring the concrete, but in such cases tubes should be arranged around the bolts so that they have a little freedom sideways for accommodating any discrepancies in the centres of the cored holes of the engine-bed. The foundation should be allowed to stand one to three weeks, depending upon its size, before any weight is placed on it, so that it may set uniformly.

The dimensions of the foundation for an engine are usually given by the makers for average soils, with the concrete resting on a gravel bed; but before making a foundation the character of the soil should always be considered. If after the excavation is made the soil does not appear quite safe for taking much weight, then the area of the concrete block at the bottom must be increased, and it may even be

necessary to drive piles into the ground. In order to avoid vibration it is most important that the nature of the subsoil be investigated, and if any doubt exists the makers of the engine should be consulted. The depth of the foundation must always be carried below the frost line, which in cold climates may be six feet deep or more. If the foundation is built on soft or made-up ground, or if the block is weakened by the necessity of having a race for the engine flywheel, then the block should be strengthened by steel girders or rails being embedded transversely. Also if the foundation is being made in close proximity to buildings, where it is essential that there shall be no vibration, the makers of the engine should be consulted.

### Foundation Bolts.

An ordinary foundation bolt is shown in Fig. 1, and it consists of a long bolt threaded at one end, and the other end squared and a hole through for receiving a cotter, above which the foundation plate is held. Fig. 2 shows the shape of the square hole usually left for receiving the foundation bolts and plates, and Fig. 3 is another form of this hole. When the bolts are placed in position before the foundation is made they should be arranged as shown in Fig. 4, and care taken to see that they project sufficiently above the concrete.

When the foundation has set the engine can be placed in position and carefully levelled up by means of iron wedges. The nuts can then be screwed on the foundation bolts, which were placed in position before the engine, then the holes left in the foundation can be filled in with concrete, also the top of the foundation block can also be floated with concrete. This process is called "grouting in." The

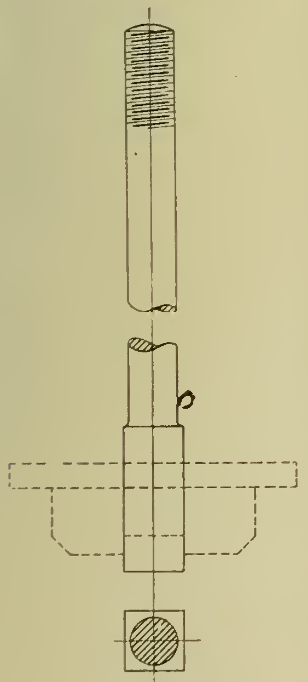


Fig. 1

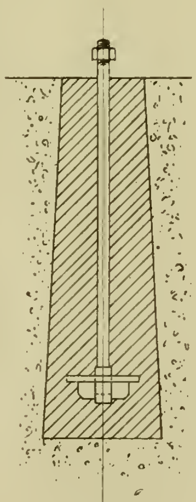


Fig. 2

Engine Foundations.

proportions of this concrete for grouting purposes is usually one part of concrete to two parts of sand, the same mixture being used for floating the top of the foundation, the latter being done by means of boards to form a ledge around the foundation, and care must be taken to see that the concrete covers the whole surface of the foundation uniformly. This grouting should be allowed two or three days for setting before tightening the nuts on the foundation bolts and before running the engine; also it is advisable not to remove the wedges used for levelling up the engine.

The surface of the concrete above the floor level will not be very smooth, and the appearance is sometimes improved

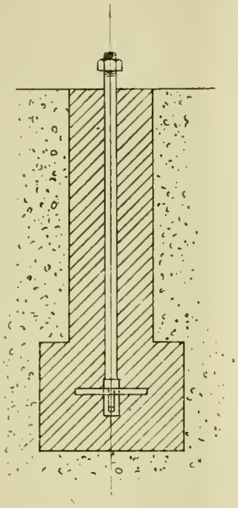


Fig. 3.

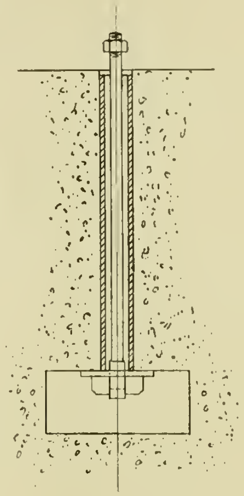


Fig. 4

Engine Foundations.

by bush-hammering the surface, or when an exceptionally good appearance is required facing bricks are used. The raised concrete foundation above the floor level has sometimes been covered with sheet lead, which in addition to giving a very good appearance also protects the concrete from oil. This protection is very necessary, as any oil that gets on to the concrete will soak into and disintegrate it, and cases have been known where the whole upper part of a foundation has had to be renewed.

## NOTES ON PISTON AND SMALL-END LUBRICATION IN DIESEL ENGINES.*

By G. B. Vickers.

Lubricating troubles are best considered under two headings, namely, unsuitable lubricating oil and faulty design.

### Lubricating Oils.

The lubricating oils should be carefully chosen. Pure mineral or hydrocarbon oils are undoubtedly the best. They contain a much smaller percentage of acid than animal or vegetable oils. The deposit from mineral oils is more easily rubbed off the bearing surface when the load comes on that animal or vegetable oil deposits. Many compound oils are good, but although they may be carefully blended originally, there is, after repeated use, sometimes evidence of disintegration, and they are liable to give a gummy deposit. It has been found by many engineers on Diesel installations that oils which are otherwise very suitable are the cause of considerable liner wear. The best test of lubricating oil is on the air compressor. If the oil causes pitting on the compressor valves and shows an acid scouring action on the valves in the air bottle heads, the main cylinder liner wear may

* Abstract of a paper read before the Diesel Engine Users Association.

be excessive. Regarding the amount which may be taken as average liner wear, figures taken from a number of engines give a mean wear of 0·010 in. to 0·012 in. per 1,000 hours' run when the engine is heavily taxed. The lubrication requirements of the small-ends and the pistons are contradictory. For pistons, an oil with a moderate viscosity of, say, 130 to 180 at 140 deg. Fah. gives good results, whilst an oil with a good viscosity of, say, 400 to 500 at 140 deg. Fah. is best for small-end lubrication.

The lubricating oil used for pistons or small-ends should not emulsify, so that if any water drops in the crank pit, it can afterwards be separated. Most mineral oils are easily separated from the water. When a different oil is used for top-end lubrication than is used for the piston, care should be taken that the oils will blend. Some oils are impossible to compound. On average engines the quantity of lubricating oil used is kept as low as possible by using new oil on the small ends only and filtered oil on the other parts. This filtered oil has advantages, as after running and filtering the bituminous matter in the oil is eliminated. Filtered oil should not be used too often on the pistons, as its viscosity gets too low for this work.

The usual method of piston lubrication is through four or six stems or quills leading through the water jacket to the liner. The customary method has been to connect each of the quills by a common feed pipe, past a back-pressure valve to the single lubricating pump. Some engineers now insist on having a separate feed to each quill.

Many piston seizures have been caused by faulty arrangement of lubricating piping and leaky back-pressure valves. The lubricating pumps for piston lubrication are in the majority of cases driven from the camshaft and so are placed much higher than the quill line. The result is, after a short stoppage, the feed piping has been drained, and unless there is wasteful flushing through, the piston does not receive any lubrication for a few minutes after starting. This difficulty has been overcome by curving the feed pipe so that it is unable fully to drain itself, or by fitting small valves which are shut off when the engine stops. A better plan is to have the lubricators fixed well below the lubricating belt line and worked off the indicator gear or the vertical shaft, thus ensuring that the pipes are always charged. The method of securing the quills is sometimes the cause of trouble. Some makers prepare a tapered hole in the liner, and the quill has a rounded nose and is screwed home tight through a tapped hole in the water jacket. When the parts get warm and expand, these quills have been found to act as struts and have caused piston seizures immediately opposite to the lubricating holes. An improved method is to have the quill screwed into the liner, a plain hole in the water jacket and an external joint made. The telescopic quill is an improvement over either of the previous methods.

**Top-end Lubrication.**

Phosphor-bronze bearings are usually adopted for the top-end bearings. The pressures are too great for white metal to be successful. The wear on phosphor-bronze bearings is seldom more than 0·001 in. per year, whilst white-metal bearings, according to the quality, may show more wear than this in one week. It is impossible to give a definite clearance allowable at top-ends. If white metal is used, no clearance should be allowed; after running the engine light for a time, the bearings then run quite satisfactorily. When a phosphor-bronze split bush is used, the average clearance is 0·003 in. vertically and 0·006 in. at each side. If the bush is solid, more clearance is required, usually 0·006 in. to 0·008 in. vertically, and 0·008 in. at the sides. The gudgeon pins should be fully case-hardened at the ends, as well as on the bearing surface.

Many of the methods adopted for lubricating the top-end bearings do not appeal to the British engineer. A good designer would only adopt them as a last extremity and then only with great diffidence. Taking first the scraper system. Two grooves are cut on the bearing surface of the piston, the top of the grooves entering the small circular groove usually turned on the piston below the lowest ring in the top nest, the grooves then take the form of a half-spiral, gradually decreasing in width until they are opposite the ends of the gudgeon pin. Holes are then led through the piston to the centre of the pin, the oil gathered in one groove leading to the large diameter end of the pin and the oil from second groove being led into the small diameter end of the gudgeon-pin. Two holes are led from the centre of the pin to the top bearing surface in the usual manner.

In the banjo system the oil is led into a banjo on the side of the crank and the centrifugal force causes the oil to flow into a small receiver having a steel ball and cage. At every revolution of the crank, the ball, having a small lift, is thrown up by its inertia and allows a small quantity of oil to pass up the pipe leading to the top end; as the ball falls on to its seating it acts as a retaining valve.

The third, and most general method of top-end lubrication is to have one or two slots in the piston which pass over the leads from the oil supply pipes and holes leading from the bottom of the slots through the piston to the centre hole in the gudgeon pin. Several holes lead from this central hole in the pin to the bearing surface.

On medium and high-speed engines, a complete service of forced lubrication solves the lubrication difficulties. Regarding the top-end lubrication, the practice of fitting a lubricating pipe leading from the bottom to the top end is to be deprecated. Any external pipes tend to come loose at the joints and get broken. It is much better to have the oil passage up the centre of the connecting rod. When a priming system of lubrication is not provided, a small ball valve fitted in a cage in the hole at the bottom end of the connecting rod acts as a retaining valve when the engine is shut down and prevents the oil from draining away from the top end.

Although the forced lubrication on all the bearings effectively solves the problem of top-end and piston lubrication, the system has disadvantages. Unless manufacturers have taken special precautions, it is probable that the piston will receive too much lubrication. The oil is thrown from the bottom-end bearings on to the liner walls, and when the piston is on its suction stroke, the slight pressure in the crank chamber tends to force the oil past the relaxed rings, the result being that the lubricating oil is burnt and very peaky indicator cards are obtained, showing a maximum pressure frequently 100 lbs. to 150 lbs. above compresion pressure. The high consumption of lubricating oil has retarded the progress of the enclosed type of engine. The difficulties have been overcome first by guarding the bottom-end bearings to avoid splash on to liners; secondly, by preventing the oil from creeping from the top-end bearing along the gudgeon pin keyway on to the piston surface; thirdly, by providing scraper-grooves on the piston with return ducts to the inside; fourthly, by dissipating the vapour in crank chamber, this vapour tending to get past the rings on suction stroke.

The common method of withdrawing the oil vapour in the crank chamber is to take the air compressor suction or the main cylinder suction from the chamber. It is found, however, that the vapour is most effectively withdrawn by a belt-driven extraction fan and the gases are led to a baffle box where they are condensed, thus recovering the oil which by other methods is burnt. The vapour is mainly caused by the oil being splashed on the inside of the piston crown, and if the crown has an oil guard fitted the vapour is considerably reduced.

# New Companies Registered.

EBORA PROPELLER CO LTD. (145,613).—Private company. Registered December 22nd. Capital, £4,000, £1 shares. To adopt an agreement with Jan Schiere, and to carry on the business of manufacturers of propellers and other parts of and accessories to aeroplanes, airships, and aircraft, flying machines of all kinds, etc. Directors: Jan Schiere, S. Cole, and F. B. Darocle. Qualification, £1,000. Secretary: R. P. Martin. Registered office: 11 and 12, Surbiton Park Terrace, Kingston-on-Thames

FYLDE ENGINEERING CO. LTD. (145,615).—Private company. Registered December 22nd. Capital, £5,000, £1 shares. To take over the business of general engineers carried on by J. Clayton and C. C. Humber at the Vulcan Works, Preston Old Road, Great Marton, Blackpool, as "James Clayton." Directors: J. Clayton, C. C. Humber, and T. Humber. Solicitor: W. J. Read, 30, Abingdon Street, Blackpool. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

ELIAS (ENGINEERS) LTD. (145,529).—Private company. Registered December 13th. Capital, £3,000, £1 shares (500 preferred). To take over the business of automobile and general engineers carried on by A. E. Elias, T. C. Elias, and H. S. Elias at the Vulcan Engineering Works, The Quay, Gloucester, as "A. E. Elias, Sons and Co." Directors: A. E. Elias, T. C. Elias, and H. S. Elias (all permanent). Qualification, £100. Solicitors: Coren and Scott, Gloucester. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

T. P. POLLITT AND CO. LTD. (145,566).—Private company. Registered December 18th. Capital, £1,000, £1 shares. To take over the business of electrical, mechanical, and general engineers, contractors, etc., carried on at Fish Dock Road, Grimsby, as Pollitt and Co. Directors: T. P. Pollitt and Mrs. M. Pollitt. Registered by Alfred H. Atkins, 27-8, Fetter Lane, E.C. Registered office: Fish Dock Road, Grimsby.

DAVIE BROS LTD. (9,724).—Private company. Registered in Edinburgh on December 13th. Capital, £2,000, £1 shares. To take over the business of Davie Bros., engineers, machine tool and general machinery merchants, etc. Directors: W. Davie and G. Davie. Qualification, 100 shares. Solicitor: D. C. Cleghorn, Glasgow. Secretary: G. Davie. Registered office: 436, Argyle Street, Glasgow.

J. N. GOUDIE LTD. (9,721).—Private company. Registered in Edinburgh on December 11th. Capital, £2,000, £1 shares. To take over the business of an engineer and maker of lifting and loading appliances carried on by J. N. Goudie at Hunter's Quay, Dunoon. Directors: J. N. Goudie and A. Thomson. Qualification, £100. Solicitor: C. Crowther, London. Registered office: Hunter's Lodge, Hunter's Quay. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

RICHARD W. LEWIS AND SONS LTD. (9,730).—Private company. Registered in Edinburgh, on December 28th. Capital, £20,000, £1 shares. To carry on the business of engineers, boiler makers, etc. Directors: R. W. Lewis, J. W. Lewis, Elizabeth W. Lewis, R. W. Lewis, junr., Ann Lewis, Ann G. Lewis, Hannah Lewis, William W. Lewis, and Kate L. Lewis. Qualification, £1. Solicitor: G. A. Wright, Edinburgh.

## FOREIGN (ENEMY) FIRM.

AMORDUCT MANUFACTURING CO. LTD., 6, Farringdon Avenue, E.C., electric cable and conduit manufacturers.—Controller: John Paterson, 1, Walbrook, E.C. (Jan. 1st—396).

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

### AFTER-THE-WAR TRADE.

*To the Editor of "The Industrial Engineer."*

Sir,—Not less important than the reorganisation and speeding up of our industrial system at home in readiness for the post-war commercial campaign is the complete remodelling and extension of our official agencies overseas.

Though there are numerous Government Committees appointed to devise ways and means for financing overseas contracts, nothing has yet been done officially to reorganise and extend our Consular system and multiply the number of His Majesty's Commissioners. We have far fewer Trade Commissioners than we should have, and those already engaged spend more time in compiling useless statistics than in actively extending British trade. The fault lies not so much with the men as with the system.

The Associated Chambers of Commerce have recently presented a Report to the Government embodying recommendations for drastic reforms in these directions, but they do not appear to have considered the question of the establishment of permanent exhibitions of British manufactures abroad. In our judgment, any scheme of reorganisation that fails to provide these institutions in the great foreign and Colonial buying centres will lack the chief essential to success. It cannot be too strongly impressed upon the Government and the British manufacturer that the overseas buyer wants to see the goods he is buying. That is half the battle! For the rest, quote him figures in his own currency, at prices that include delivery at his nearest railway depôt, with reasonable credit based upon the custom of the country, and no amount of competition that we are likely to meet, East or West, will seriously stand in the way of our highly-organised workshops.

The Board of Trade has recently issued thousands of invitations to overseas buyers to visit the great Trades Exhibition to be held here in the Spring. This is, in itself, no small tribute to the "pulling power" of the exhibition, but it is at the same time a confession of weakness. It would be infinitely better to take the exhibitions to the people overseas than to bring the people to the exhibitions.

Permanent exhibitions to which overseas buyers can go every day are vastly superior to annual displays thousands of miles away, to which not a thousandth part of the overseas buyers will ever come.

Just before Mr. Asquith's Government collapsed it was announced in the House of Commons that such exhibitions for the chief buying centres in Canada were "under consideration," but as nothing has since been heard of the proposal, it has probably followed in the wake of the Government.

We want these institutions all over the habitable globe, and if we can get them established, they will, in our judgment, do more to boost British trade and keep our machinery employed after the war than any other agency that we can put into the field.

Such a scheme, if properly organised, would be largely self-supporting. Tens of thousands of British manufacturers who find it impossible to open and staff overseas branches would readily spend a few hundreds of pounds per annum for business spaces and trade representation in exhibitions in the world's buying centres. The nearest approach to the idea that we know of is to be found in the Civic Industrial Bureau, organised by the Winnipeg Municipality, and the later developments of the Canadian manufacturers, who, we understand, are not only organising a permanent exhibition of their wares in London, but are arranging to run an exhibition train through France.

Apparently, all we want here, as elsewhere, is a Government lead, and now that the more active spirits are in power, let us hope that we may get it.—Yours truly,

Barimar Ltd.

(Scientific Welding Engineers).

(C. W. Brett, Managing Director and General Manager.)

January 17th, 1916.

# Patent Applications.

*The following Notes and Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

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## COMPLETE SPECIFICATIONS ACCEPTED.

*Under a new system the specifications of patents are re-numbered on acceptance of the complete specification. The new number is in heavy type, and specifications should be ordered under this number.*

**1916.**

70—Hamilton, J. E.: Electric controller. **102,981.**
108—Burgess, S. R., and Gordon, C.: Internal-combustion engines. **102,982.**
129—Ionides, A. C.: Complete combustion of gaseous mixtures. **102,983.**
135—Saurer, A. )F
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366—Heppel, W. G.: Controlling length of stroke in pumps. **102,516.**
4,082—Albion Motor Car Co., and Murray, T. B.: Friction clutches. **103,041.**
5,257—Back, A. B.: Sparking-plugs. **103,051.**
5,763—Wade, H.: Gear pumps. **103,053.**
6,190—Walker, F.: Vaporisers. **103,056.**
6,423—Grabhill, J. F., Chaffin, H. C., and Arbuthnot, E. H.: Steam valves. **103,058.**
8,633—British Westinghouse Electric and Manufacturing Co.: Alternating current commutator motors. **100,743.**
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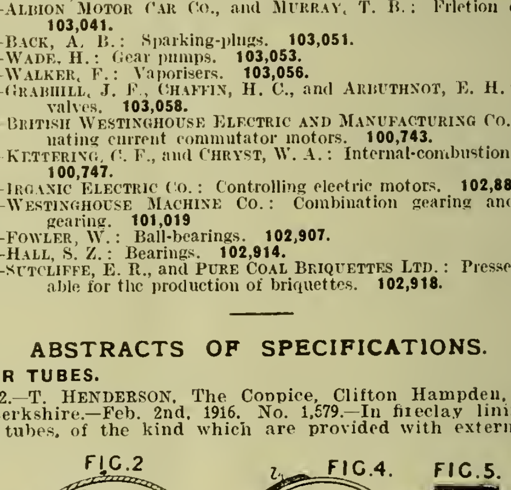
9,827—Westinghouse Machine Co.: Combination gearing and thrust gearing. **101,019**
12,337—Fowler, W.: Ball-bearings. **102,907.**
13,944—Hall, S. Z.: Bearings. **102,914.**
15,601—Sutcliffe, E. R., and Pure Coal Briquettes Ltd.: Presses applicable for the production of briquettes. **102,918.**

## ABSTRACTS OF SPECIFICATIONS.

**BOILER TUBES.**

101,572.—T. Henderson, The Coppice, Clifton Hampden, Abingdon, Berkshire.—Feb. 2nd, 1916. No. 1,579.—In fireclay linings for boiler tubes, of the kind which are provided with external pro-




jections to form an annular space between the lining and tube and also with perforations for the passage of gases, the projections and perforations are arranged helically, and the lining is

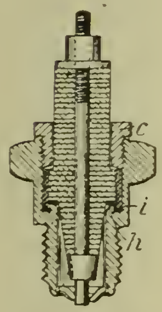
made up of semicylindrical sections with fire-clay rings between the ends of adjacent sections. such rings being also provided with helical ribs inside and outside if desired. As shown in Figs. 2 and 3, the lining is formed of semicylindrical sections $a1$, $a2$, the parting edges of which are slightly thickened as shown at $c$ and provided with projections $d$ to engage with recesses in rings $b$. Figs. 4 and 5. The lining is made with perforations $e$, some of which are provided with projections $f$. The rings $b$ are provided with external ribs $i$ and internal flanges $k$ arranged helically. The semicylindrical portions $a1$, $a2$ may also have helical ribs on their inner surfaces.

### SPARKING PLUGS.

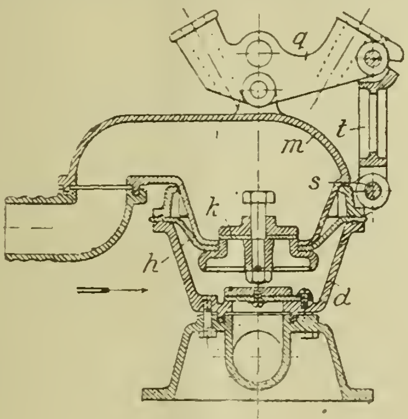
101,828.—A. T. AUSTIN. Hudson's Road, Cotteridge, King's Norton, Birmingham.—March 1st. 1916. No. 3,062.—The abutting shoulders on the casing and insulator are formed with interengaging annular recesses and projections $h$ $i$. The insulator projection may be formed by wrappings of mica. A similar connection may be formed between the gland nut $c$ and the outer end of the insulator, and copper-asbestos or other washers may be interposed.

### PUMPS.

101,844.—V. MOLLER. Svendborg, Denmark.—June 1st. 1916. No. 7,765.—In the pump shown, the pump body $m$ is connected to, and moves with, the diagram $h$, which carries the delivery valve $k$. The part $q$ which receives the hand-operating bars is pivoted to the body $m$ and to a lever $t$ pivoted at $s$ on a stationary part $d$ of the pump.



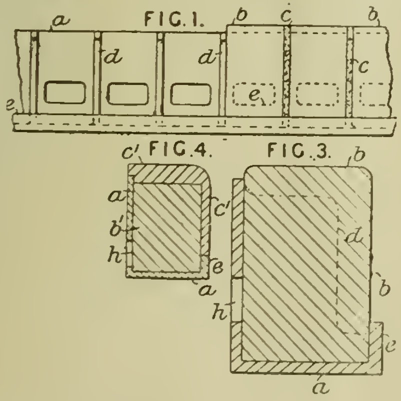

Patent 101,828.




Patent 101,844.

### FURNACES.

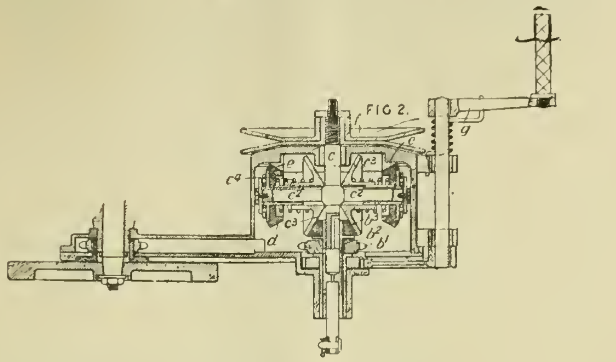
101,493.—J. P. Tye, 176, East India Road, Poplar, London.—Jan. 31st, 1916. No. 1,460.—In a fire-bridge comprising a metal frame of approximately L-shaped section having a lip or flange at the front to assist in holding in position refractory blocks or filling material supported by the frame, and also having transverse strengthening partitions or ribs arranged inside the frame, the partitions or ribs are formed substantially rectangular in shape,




and hand-holes are provided in the back of the frame to facilitate repairs or the removal of broken material. As shown in Figs. 1 and 3, the frame $a$ having a lip $e$ and supporting blocks of refractory material $b$, is provided with rectangular partitions $d$ which do not extend as far as the top or front faces of the bridge, so as to leave spaces between adjacent blocks for fireclay filling $c$. Hand-holes $h$ are provided for the purpose mentioned above. In the modification shown in Fig. 4 the fireclay filling $b1$ between the partitions is provided with a fireclay covering $c1$.

### VARIABLE-SPEED EPICYCLIC GEARING.

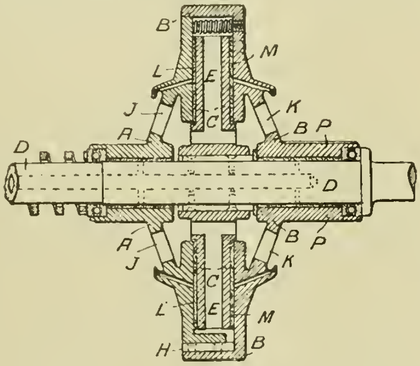
101,897.—G. J. DALLINSON, 107, Doidge Road, Erdington, Birmingham.—Jan. 18th 1916. No. 771.—Relates to epicyclic variable speed gearing for motor cycles, etc., in which the variation is obtained by the employment of conical expanding-wheel friction gearing. A shaft $b2$, sliding within a chain-wheel $b1$ driven from a shaft $c$, carries a friction cone $b3$ engaging conical discs $c3$ carried on two, three, or more radial arms $c2$ on the driven shaft $c$ on which is secured a transmission pulley $f$. The discs $c3$ turn with friction rollers $d$ engaging a fixed conical track $e$. By sliding the shaft $b2$ inwards, the discs $c3$ are pressed radially against the action of springs $c4$, and the speed is increased. The rollers




$d$ may be arranged between two similar fixed tracks $e$, the shaft $c$ being adjustable to engage the rollers with the second track and reverse the drive. A kick starter $g$ may be provided.

### FRICTION GEAR.

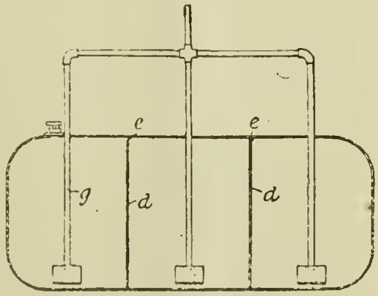
108,918.—J. D. THOMSON and G. THOMSON, West End Engine Works, Dundee Street, Edinburgh. March 17th, 1916. No. 3,974.—A friction gear which permits slip of the driven member, applicable for driving winding-reels for paper or other material, to which the material is fed at a constant speed, is cooled by the circulation of air. A central member C, secured to the shaft D




for driving the reels, etc., is driven by two spring-pressed side members, A, B, loose on the shaft D, but slidably connected together and driven by a pulley on the sleeve P of the member B. Air for cooling circulates through passages J, K in the members A, B, curved passages E in the member C, and passages H between the side members. A non-conducting and frictional material L, M, preferably "bonded asbestos," is placed between the members.

### INTERNAL-COMBUSTION ENGINES.

101,984.—J. HIGGINSON and H. ARUNDEL, Sovereign Works, Stockport, Cheshire.—Jan. 5th, 1916. No. 200.—Store tanks, from which the fuel is withdrawn by suction into another tank that supplies the carburettor, are divided into compartments by partitions $d$



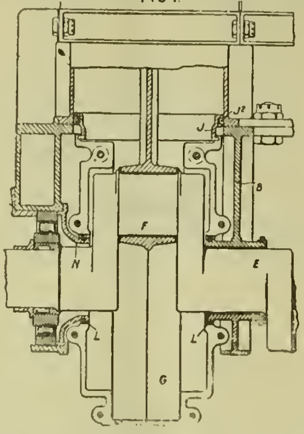

having apertures $e$ at the top, so that if the tank is damaged in one place, the oil will flow from one compartment only. The suction pipes $g$ are fitted with float valves which close when the compartments are emptied and prevent oil from entering from another compartment.

### INTERNAL COMBUSTION ENGINES.

101,997. A. CRAIG, Earlsdon House, Earlsdon, Coventry. Feb. 16th, 1916. No. 2 311.—In engines of the kind in which the crankshaft E is supported by hangers B from the cylinders each crankpin F moves in a separate detachable oiltight casing G made in four parts and bolted together. The casing is connected to a ring J, which is supported in a floating manner inside the cylinder and provided with a packing-ring J2. A similar packing-

ring L is placed between the casing and the hanger or a sleeve N attached thereto. According to the Provisional Specification, an approximately semi-circular channel-shaped shield is pro-

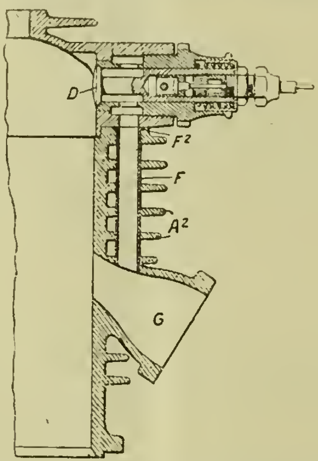
FIG I.



vided in the plane of each crank throw with its open ends attached to the cylinder, and the space between the shield and the hangers is enclosed by a flexible wall.

### INTERNAL-COMBUSTION ENGINES.

102,002.—VILLIERS ENGINEERING CO., Villiers Works, Blakenhall, Wolverhampton, and G. FUNCK, "Violette," Quinton Road, Coventry.—Feb. 23rd, 1916. No. 2,707.—The gases escaping from the

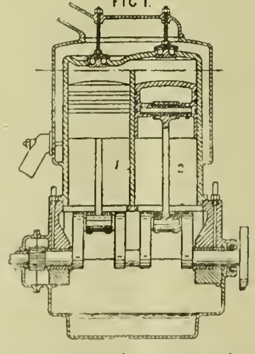


compression relief valve D are led to the exhaust pipe G of a two-stroke-cycle engine through a pipe F which fits a hole bored through the cooling-fins A2. When the cylinder head is detachable, it secures the pipe F by bearing on its flange F2.

### INTERNAL-COMBUSTION ENGINES

102,004.—L. C. VAN RIPER, 59, Long Acre, London.—Feb. 28th, 1916. No. 2,982.—In an engine having a pair of pistons acted upon simultaneously by each impulse and connected to cranks making with each other an angle of from 20 to 95 degrees, the communicating-passage between the two cylinders is distinguished by the absence of valves. Ignition occurs preferably when the two

FIG I.



pistons are equi-distant from the upper dead-centre. Inlet and exhaust valves are provided in the cylinder 2, and an air scavenging-valve in the cylinder 1. The cylinders may be arranged in the form of a V, or they may rotate. As shown in Fig. 1, the clearance in the cylinder 1 is less than in the other cylinder.

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THE

# Industrial Engineer.

VOL. V.] FEBRUARY 8TH, 1917. [No. 128.

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# EDITORIAL.

## THE NATIONAL ALLIANCE.

THE National Alliance of Employers and Employed is another of the organisations which have arisen out of the necessities of the war. This, the latest of organisations, should receive a hearty welcome by both the representatives of Capital and Labour, as it is capable of doing a vast service to both these classes in the settlement of those thorny industrial problems which will inevitably arise immediately peace is declared. Nothing but the boldest statesmanship will require to be exercised by everyone concerned in industrial problems as they will be presented after the war, for we think it is becoming more generally recognised day by day that the old industrial conditions of pre-war days will not by any means suffice for the carrying on of industry after the war. In fact, hardly anything in life will be the same, the changes already made and those which we see to be necessary in future are and must be difficult. We shall, therefore, be bound to approach the coming problems with an earnest endeavour to effect a solution which will alike be satisfactory to the capital employed, and to all the forms of labour used in making such capital a source of profit to the investor and to the captains of industry, and those directly under their charge.

### Demobilisation and Reinstatement.

One of the greatest and perhaps one of the earliest of the problems to be solved will be that of demobilisation and the reinstatement in industry of those who have done their bit in the war and have been fortunate enough to come through to be of after-service again in the ranks of industry in the positions which they, either voluntarily or forcibly, relinquished to fight the battles of those who stayed at home. In the settlement of this important problem alone the National Alliance of Employers and Employed can play an important and useful part. In fact, no body outside these two great classes can do the work so well or effectively, since the very nature of their interests, in the two sides of this important question, is sufficient evidence that they must indubitably know better than any other body what is required to bring the naturally conflicting views into line.

The meeting held yesterday in Manchester is, to our mind, a happy augury of what will be accomplished. No one, we think, could say that the various interests and views were not adequately represented, from the realms of high finance to the humble and hard-working stoker of a commercial liner or battleship, with all the other classes intervening between these two extremes. Men of practically all views were present, from those who are known to express extreme opinions on labour questions pure and simple to those who deal delightedly in the various phases of political economy. There is room amongst all these to ensure that all views can be expressed; but wherever there arises a tendency for extremity of opinion to become dominant it should be put down with a stern hand to allow for concentration on points that are generally acceptable. We hope, therefore, that this will be kept strictly in mind, and if it is we look forward to a happy solution of the labours of this new alliance.

# TRIALS ON A DIESEL ENGINE, AND APPLICATION OF ENERGY-DIAGRAM TO OBTAIN HEAT BALANCE.

By the late Lieut. F. Trevor Wilkins (Northumberland Fusiliers), M.Sc., of the University of Birmingham, Graduate.

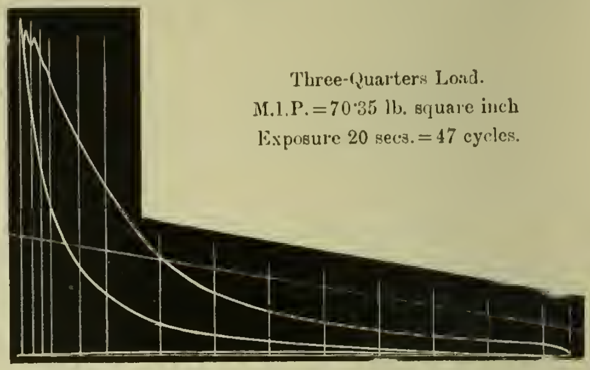
(*Continued from page 145.*)

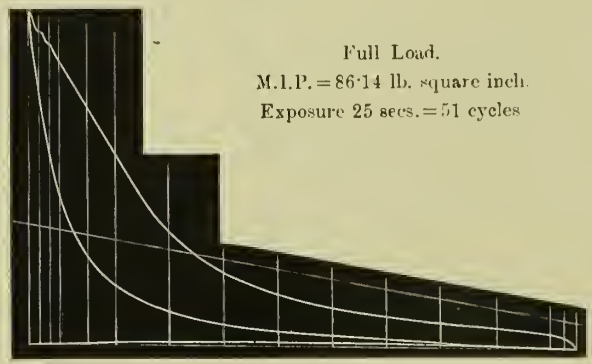
## Variation of Temperature in the Engine Cylinder.

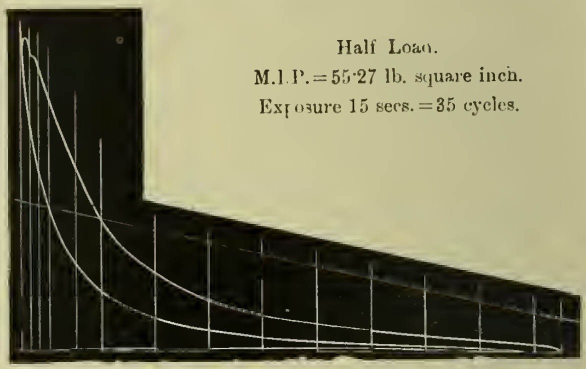
Temperature curves, Figs. 9 and 10, have also been drawn both on stroke and on crank-angle or time bases. These curves and the original compression curve on the energy diagram indicate clearly the small rise of the temperature of the charge with this diameter cylindeer when the pressure on the compression stroke exceeds 300 lbs. per square inch. Towards the end of compression the temperature appears to be constant for a short time and finally to fall slightly. This fall is shown clearly, and may be due either to the large surface and relatively small volume of the gases at top dead-centre, or to the cooling effect of a sprayof cold injection air coming in when the fuel-valve is opening.

## Volumetric Efficiency.

The volumetric efficiencies are worked out upon volumes of air taken at 760 millimetres pressure. It will be noticed




Sample Indicator-Diagrams obtained in Main Tests. (Reproduced direct from optical diagrams.)

TABLE 5.

Volumetric Efficiency and Charge Quantities.

| Description. | Units. | Half Load. | Three-quarters Load. | Full Load. |
|---|---|---|---|---|
| Meter Reading corrected to 60 deg. Fah. and 760 mm. ...... | cu. ft. per hr. | 1510 | 1490 | 1470 |
| Volume of Charge per cycle ........ | cu. ft. | 0·1818 | 0·1805 | 0·1802 |
| Weight of Air Charge per hour ........ | lb. per hr. | 112·27 | 113·72 | 115·42 |
| ,, ,, ,, cycle ........ | ,, | 0·01383 | 0·01378 | 0·01376 |
| Volumetric Efficiency on total vol. of cycle ........ | per cent | 84·2 | 83·7 | 83·6 |
| ,, ,, ,, inlet-valve closing ........ | ,, | 87·1 | 86·55 | 86·4 |
| Temperature at end of suction (on piston sweep) ........ | Deg. Cen. Abs. | 324 | 325 | 326 |
| Injection Air per hour ........ | lb. per hr. | 6·86 | 6·5 | 5·13 |
| ,, ,, cycle ........ | lb. | 0·000825 | 0·000788 | 0·000629 |
| Oil ........ | lb. per hr. | 2·093 | 2·686 | 3·389 |
| Oil, weight per cycle ........ | lb. | 0·00025124 | 0·0003255 | 0·0004155 |
| Hydrogen, weight per cycle ........ | ,, | 0·00003768 | 0·00004882 | 0·00006232 |
| Carbon ,, ,, ........ | ,, | 0·0002135 | 0·0002766 | 0·0003531 |
| Equivalent Charge-weights— | | | | |
| Air Charge per cycle ........ | ,, | 0·013476 | 0·013378 | 0·013358 |
| Injection Air per cycle ........ | ,, | 0·0008009 | 0·000765 | 0·0006106 |
| Carbon per cycle ........ | ,, | 0·000498 | 0·000645 | 0·000824 |
| Hydrogen per cycle ........ | ,, | 0·0005276 | 0·0006835 | 0·0008725 |
| Total Charge-weight per cycle ........ | ,, | 0·015303 | 0·015472 | 0·015665 |

Note to Table 5.

| | |
|---|---|
| Total Vol. of Cylinder ........ | 0·2158 cu. ft. |
| ,, ,, ,, when Inlet Valve closes ........ | 0·2083 ,, |
| Volume of Clearance ........ | 0·1119 ,, |
| ,, Piston Sweep ........ | 0·2039 ,, |

that they are high, and that the temperatures necessary to fill the cylinder are low. The correction for hot residuals will therefore be small enough to be negligible. A general check on the temperature figures is given by the comparisons of the thermal efficiencies obtained directly and by means of the energy-diagram.

**Determination of True Percentage Balance Sheet.**

By combining the figures obtained from the indicator and energy-diagrams, the true percentage heat balance-sheet may be obtained and compared with the apparent balance-sheet obtained directly from the test results. The procedure followed in working out the figures is self-explanatory from the tables.

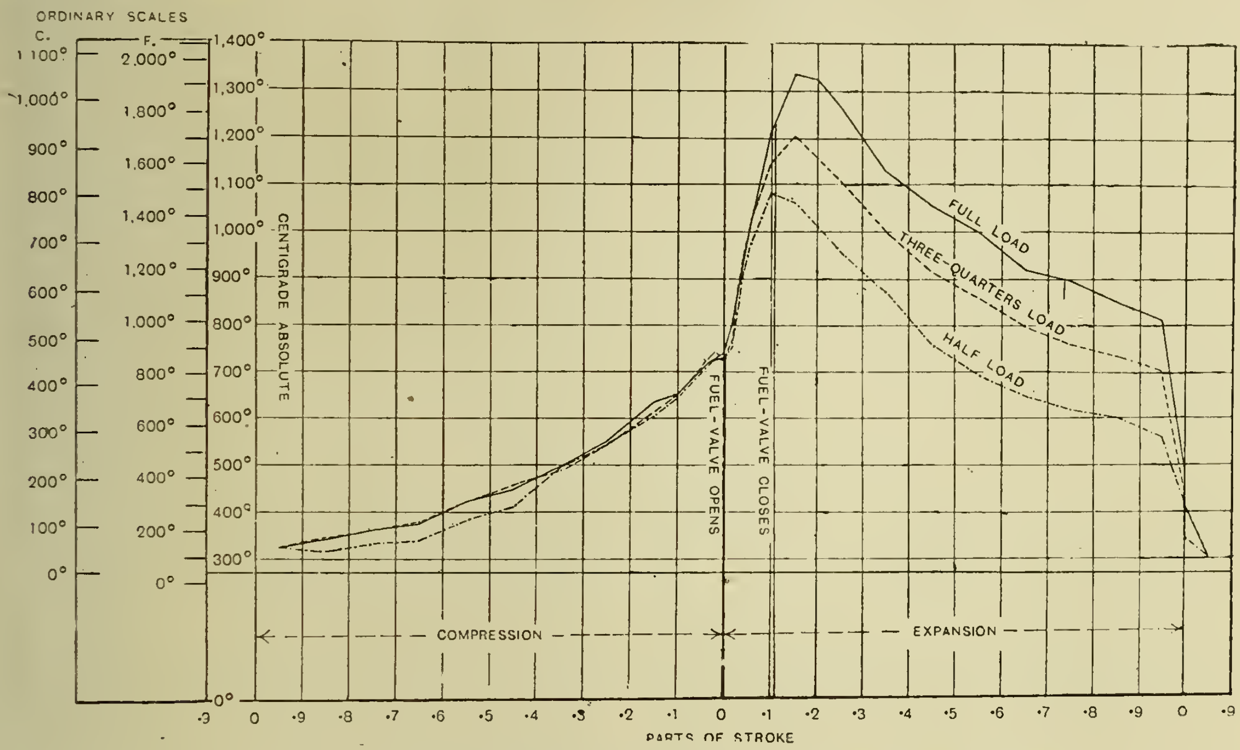



Fig. 9.—Temperatures in Cylinder of 8 B.H.P. Diesel Engine on Stroke Basis. University of Birmingham, 1913.

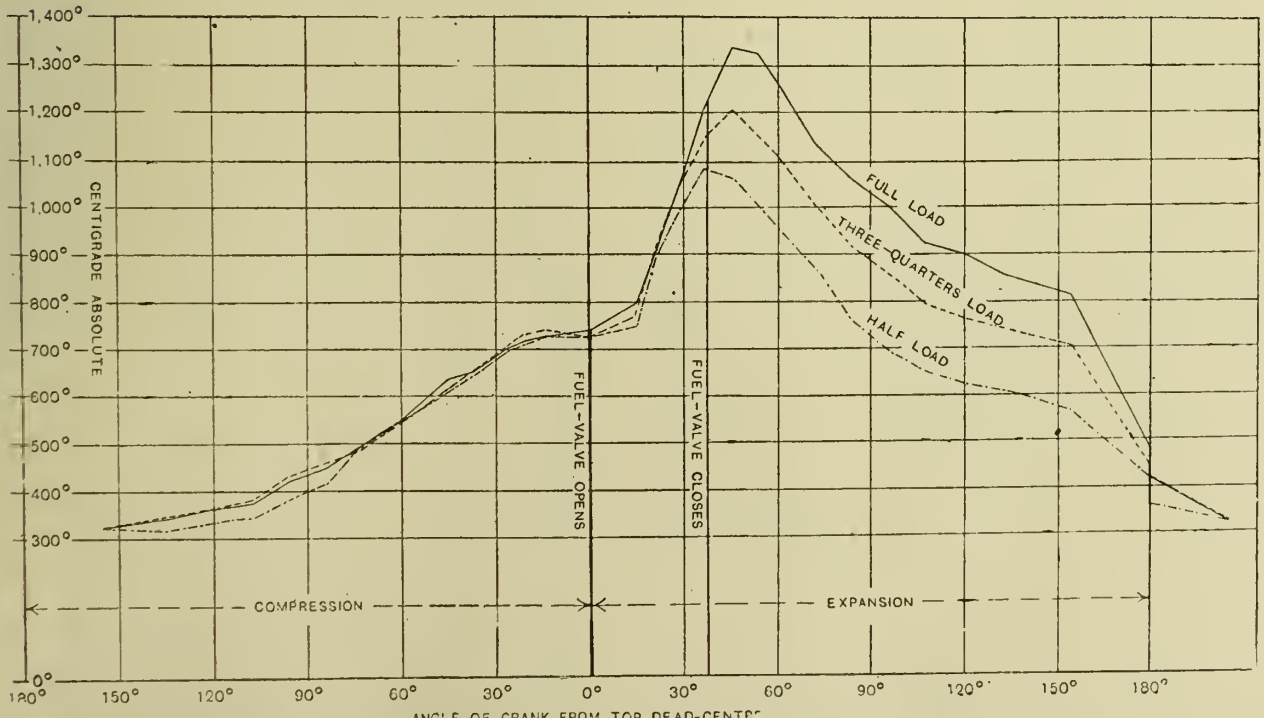



Fig. 10.—Temperatures in Cylinder of 8 B.H.P. Diesel Engine on Crank Angle Basis.

TABLE 6.

Determination of True Percentage Heat Balance-Sheet.

| — | Half Load. | Three quarters Load. | Full Load. |
|---|---|---|---|
| | Quantities in foot-pounds. | | |
| Work area under Expansion Curve | 3901 | 4264·6 | 4728·6 |
| Work area under Compression Curve | 2151·05 | 2195·1 | 2170·7 |
| (A) Useful Work per cycle | 1749·95 | 2069·5 | 2557·9 |
| Heat to Jackets on Expansion | 46·76 | 273·98 | 753·76 |
| „ „ Compression | 832·02 | 907·3 | 768·04 |
| (B) Total Heat to Jackets | 878·8 | 1181·3 | 1521·8 |
| (C) Total Heat to Exhaust | 1036 | 1460·2 | 1939·7 |
| Total Heat per cycle— (A + B + C) | 3664·7 | 4711 | 6019·4 |

From the figures in lines A B C the true percentage heat balance-sheet can be determined :—

| — | Half Load. | | Three-quarters Load. | | Full Load. | |
|---|---|---|---|---|---|---|
| | Energy-Diag. | Test Results. | Energy-Diag. | Test Results. | Energy-Diag. | Test Results. |
| Thermal Efficiency | 47·7 | 44·5 | 44·0 | 43·8 | 42·5 | 42·1 |
| Heat to Jackets | 24·0 | 32·2 | 25·1 | 29·2 | 25·3 | 29·6 |
| Heat to Exhaust | 28·3 | 23·3 | 30·9 | 27·0 | 32·2 | 28·3 |
| Totals ... | 100·0 | 100·0 | 100·0 | 100·0 | 100·0 | 100·0 |

Attention is directed to the discrepancies between the figures obtained by each method for the value of the percentage indicated thermal efficiency. The differences provide an indication of the accuracy with which the measurements and graphical operations were carried out.

TABLE 7.

Amount of Heat Extracted from Exhaust Gases by Cylinder Cover.

| — | | Half Load. | Three-quarters Load. | Full Load. |
|---|---|---|---|---|
| Heat of Jackets.. (Diagram) | ft. lb. | 878·8 | 1181·3 | 1521·8 |
| „ „ (Trials by diff.) | ft. lb. | 1173 | 1375 | 1781 |
| Difference | ft. lb. | 157·2 | 193·7 | 259·2 |
| Percentage amount | ft. lb. | 13·4 | 14·1 | 14·5 |

The differences at the same load in the percentage amount of heat going to the jackets in Table 6 are, of course, due to the fact that the cooling water extracts a large amount of heat from the exhaust gases on the exhaust stroke, as these gases, besides flowing round the exhaust-valve, are directed to the outlet round a right-angled bend in the cover. The numerical values of these figures are determined, and attention is directed to the fact that the amount of heat extracted by the cooling water from the exhaust gases, expressed as a percentage of the total heat given to the cooling water, is remarkably constant.

### Heat-Flow during Compression.

It will be seen in Table 8 that the figures for the heat-losses to the jackets are quite irregular, but, as may be supposed, the heat-loss at full load is appreciably less than at other loads.

TABLE 8.

Heat-Flow During Compression.

| — | | Half Load. | Three-quarters Load. | Full Load. |
|---|---|---|---|---|
| Loss to Jackets | ft. lb. | 832 | 907 | 768 |
| Work done on Compression | ft. lb. | 2151 | 2195 | 2170·7 |
| Percentage Lost Work | ft. lb. | 38·7 | 41·3 | 35·4 |

The author desires to express his thanks to Professor Burstall and Dr. Fisher, of the University of Birmingham, for the facilities afforded and suggestions given; to Professor Watson, of the College of Science, for the gift of two of his own diaphragms, which proved of great use in the preliminary investigations in connection with the manufacture of the diaphragms for use in the indicator; and to his fellow research student, Mr. A. U. Zimmerman, and the staff of the University for their practical assistance.

*(Concluded.)*

## NOMINAL HORSE POWER.

The Board of Trade, owing to the uncertainty and inadequacy of the formula hitherto used to define the nominal horse power of marine engines, have revised the regulations. These are embodied in a recent circular to surveyors for their guidance in respect to the engineers required for foreign-going steam vessels of 100 N.H.P. or over. The old formula is N.H.P. $= \frac{S}{30}$, where S is the sum of the squares of the diameters in inches of all the cylinders. The new formula is N.H.P. $= \frac{(3\,H + D^2 \sqrt[3]{S})\sqrt[3]{P}}{700}$; where H = heating surface of main boilers in square feet, measured down to the level of the firebars, but excluding the front tubeplate; D = square of diameter of L.P. cylinder, or sum of squares of diameter of cylinders in non-compound engines, measured in inches; S = length of stroke of engines, in inches; P = pressure of main boilers in pounds per square inch. At least two certificated engineers are required in foreign-going steamships of 100 N.H.P. by this formula.

## THE INTERNAL-COMBUSTION ENGINE.

By Dugald Clerk, D.Sc., F.R.S., M.Inst.C.E.

*(Continued from page 147.)*

Although in 1861 Schmidt in Germany and Million in France described compression engines with separate compressing pumps, no two-stroke engine appeared in public till 1879, when I exhibited my first compression gas engine at the Kilburn Show of the Royal Agricultural Society of England. This engine was patented in 1878 (Patent No. 3045). It had two cylinders, a pump and a motor, each of 5 in. diameter by 8 in. stroke. The pump compressed a mixture of gas and air into a reservoir at the full pressure required; the mixture was admitted to the motor cylinder during the first part of its stroke, cut off by valve and ignited by an incandescent platinum igniter, the piston driven forward by the explosion, and after expansion the return stroke of the piston discharged the exhaust gases. This engine was heavy for its power, and it was subject to the difficulty of back ignition into the reservoir, so that it was not placed on the market. The engine gave 3 B.H.P., however, for many months, and it is believed to be the first compression engine ever run giving one impulse for every two strokes of the motor piston.

The engine best known by my name was patented by me in 1881 (No. 1089 of 1881). It resembled Barnett's of 1838 in compressing within the cylinder and giving one power impulse for each double stroke; but it differed in applying exhaust ports at the out end of the stroke overrun by the piston to time exhaust and charging. It further differed in coupling the pump or displacer cylinder to the main crankshaft, instead of driving at twice the number of revolutions by gear wheels.

At the time when I was inventing, designing, and experimenting with two-stroke engines in Glasgow, a Northumberland man, the late Mr. James Robson, was busily at work on compression. His first patent is dated 1877, No. 2334. It describes an engine of the non-compression type; but he produced a two-stroke engine with compression, under patents dated 1879 and 1880. Messrs. Tangyes, of Birmingham, produced an engine with Mr. Robson, which was first exhibited in public by them at the end of 1880. In this engine the front end of the cylinder was enclosed and used as a pump to force a mixture of gas and air into a reservoir at a pressure of about 6 lbs. per square inch above atmosphere; the piston over-ran ports in the cylinder, but the exhaust was not timed by it; a separate valve was used which controlled the exhaust.

Siemens in 1861, and Brayton in 1873, had proposed constant pressure engines, in which the front end of the cylinder was used to compress the charge which was utilised on the other side of the piston to produce power by combustion and expansion; but Robson was first to propose the use of the front to compress lightly the charge for the compression engine of the explosion type.

The two-stroke or impulse-per-revolution engine was thus the result of the work of the English engineer, Barnett, 1838; the French engineer, Million; and the German engineer, Schmidt, in 1861; and British engineers, Clerk and Robson—Clerk by his 1878 and 1881 engines, and Robson by his 1879 and 1880 engines.

Mr. Robson's son, Mr. James Robson, of Messrs. Tangyes Ltd., published an interesting booklet in 1915 describing his father's early work, from which it appears that Robson experimented with gas engines of different types from the early date of 1855, and he rightly claims priority for his father as the inventor of one type of two-stroke engine—that in which all the pumping and motor actions are performed by one piston in a single cylinder.

Undoubtedly Mr. Robson was very early in the field, and his work was most meritorious; but the existence of Barnett, Million, and Schmidt prevented any later inventor from claiming the whole idea of impulse every revolution. Robson and Clerk both invented modifications which made the two-stroke idea practicable; but as the four-stroke cycle had been invented by Beau de Rochas, so the two-stroke idea was likewise proposed by the earlier inventors.

Messrs. Sterne and Co., engineers, Glasgow, built and sold large numbers of Clerk-type two-stroke engines, and Messrs. Tangyes, of Birmingham, a large number of Robson engines. The test of use and time, however, proved the four-stroke engine to be best adapted for most purposes, and by far the largest numbers of internal-combustion engines in existence operate according to this cycle.

Many of the larger gas engines in Germany and America operate upon the Clerk modification of two-stroke compression engine, as adopted by Messrs. Kœrting, of Hanover, and their licensees. In the inquiry made in Germany referred to already, it was proved that 260,000 B.H.P. was produced in that country in the year 1907 by four-stroke engines, and 91,000 B.H.P. by two-stroke engines.

A modification of the Robson two-stroke engine was made in England by Mr. Day in 1891, in which a crank case was used as the pumping chamber, and the piston, by means of three cylinder ports, performed all the necessary valve operations. This form of engine is largely adopted in America for launch propulsion; some motor-cars also used it. An increasing use is being made of two-stroke engines for large gas and oil engines, and this type is now firmly established and shares the field with four-stroke engines; both have advantages on some points and disadvantages in others.

The engineering commercial development of the four-stroke engine proceeded simultaneously in England and Germany. The Messrs. Crossley, of Manchester, constructed many thousands of these engines, and as the result of study and experience they made numerous improvements of an important kind. The German works, the Gasmotoren Fabrik, of Cologne, under Dr. Otto, continued the work in Germany, and this company also constructed large numbers of engines, and Dr. Otto, Herr Daimler, his works manager, and others produced important modifications and improvements. All the numerous engine works established on the Continent and in America were enabled to work successfully from the experience produced in the first instance by these two firms. The early development of the engines, however, was seriously hampered by an erroneous theory of the action of the explosion under compression held by Dr. Otto and supported in Germany by a physicist even so learned as Dr. Slaby. This erroneous theory also received support from several English scientific men of eminence. According to Dr. Otto, all gas engines previous to his four-stroke motor of 1876 obtained their power from the explosion of the homogeneous charge of gas and air. By this explosion excessive heat was supposed to be evolved, and the pressures produced rapidly fell away and the excessive heat was rapidly absorbed by the enclosing cold walls. This, Dr. Otto said, caused great loss, and gives very wasteful engines. The two methods were open to obtain better economy:—

1. By using a very rapid expansion so that the heat had but little time to be dissipated;

2. By using slow combustion, that is, by causing the inflammable mixture to evolve its heat slowly, so that the

production of excessive temperatures and pressures was avoided.

The Otto and Langen engine, with its shooting piston, obtained its economy by long, very rapid expansion; the Otto four-stroke compression engine was supposed to obtain its economy by a gradual evolution of heat throughout the stroke, produced, Dr. Otto thought, by the stratifying of a charge of gas and air in the cylinder. This false theory of the action of compression, if persisted in, would have blocked all improvement in power and economy upon the very moderate results obtained in 1876. The greater part of the credit of working out the true theory of operation of compression gas engines falls to Great Britain. A paper read by Clerk before the Institution of Civil Engineers in London early in 1882 discussed the theory of compression, and proved definitely and numerically the relative improvement in thermal efficiency to be expected by using compression previous to ignition. That paper, in fact, established the air standard of efficiency for internal-combustion motors. This was taken up later by Dr. Amie Witz, of Lille, and the whole subject was dealt with fully, so far as the knowledge at that time allowed, in a book published by Clerk in London in 1886. In that year also a paper was published at the Institution of Civil Engineers, also by Clerk, giving the results of investigations upon the different maximum pressures produced by mixtures of coal gas air ignited at atmospheric pressure within a large closed vessel. In that paper the whole subject was dealt with quantitatively, and it was proved that the conditions of economy were, so far as explosion is concerned, due to the use of moderate temperatures produced by homogeneous explosive mixtures; stratification was proved to have nothing whatever to do with economy. Other investigators took up the work of Britain, and explosion experiments with various mixtures and pressures of gas and air were made both in American and German colleges which corroborated Clerk's results. The modern improvement of thermal efficiency flows from a knowledge of the true theory of compression, and by the aid of abstract knowledge the indicated thermal efficiency in commercial internal-combustion motors has risen from 16 per cent—Otto's results in 1876—to 35 to 40 per cent—results of high-compression engines used to-day. A very important portion of the work of investigation of the conditions of gaseous explosions is due to the Gaseous Explosions Committee of the British Association. That committee was formed at the Leicester Meeting in 1907, and a great deal of important experimental work has been accomplished by its members in the nine years which have elapsed.

Notes on experimental investigation into explosion temperatures; rates of temperature rise and fall; dissociation of steam and carbonic acid; radiation during chemical combination and after; variation of specific heat of air, nitrogen, carbonic acid and steam with increase of temperature; causes of varying rates of inflammation; comparing closed vessel explosions with engine cylinder explosions, temperatures of cylinder walls and pistons; composition of exhaust gases, suction and exhaust temperatures; variation of heat loss during expansion at differing gas densities; internal energy of gases at high and low temperatures, and many other matters have been submitted and discussed by Callender, Clerk, Coker, Dalby, Dixon, Petavel, Harker, Hopkinson and Watson.

Independent chemical work, too, has been accomplished by Bone, Dixon and Smithells, while Burstall has made additional investigations on temperatures. The properties of the working fluid of the internal-combustion engine at high and low temperatures have thus become known to the engineer and inventor to assist him in making further departures intended to increase the power of those motors to compete more and more with the very large steam turbines and reciprocating steam engines of to-day.

Five reports have been published by the British Association summarising these separate investigations.

Germany has also carried out some investigations, principally at the Reichsanstalt, in Berlin. On the whole, however, the German scientific work on this subject is much inferior in importance to the British. Most valuable French work has been also done by Regnault to Mallard and Le Chatelier, Berthelot and Witz.

Some American work has also been performed, but undoubtedly the English work on the nature of gaseous explosions dealing with questions of varying specific heat, rate of heat loss to walls, effect of polished inner surfaces, radiation effect, and the discussions on dissociation have proved of vital importance to the science of this subject. Curiously enough, the German scientific men are far behind in the theory of these motors, although their practical constructors have done excellent work, even with most erroneous ideas of the nature of the forces with which they were dealing.

*(To be continued).*

## VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.*

### Introduction.

The rapid development of road locomotion after its renaissance, brought about in this country by the passing of the Locomotive and Highways Act of 1896, may be attributed to three primary causes: (1) the introduction of the high-speed petrol motor, (2) the state of perfection to which variable speed-gearing has been brought, and (3) the employment of pneumatic tyres. Although the high-speed internal-combustion engine has been dealt with in many papers read before this and other Engineering Societies, the author is not aware of any paper which has dealt exclusively and fully with the various mechanisms which have been and are employed to give a variable velocity ratio between the prime mover and the road wheels of motor road-vehicles. In his opinion the bearing which the improvements in these mechanisms has had on the rapid development in road locomotion has not been fully recognised, and the perfection to which the variable speed-gear has been brought appears to have been overshadowed by the development of the prime mover.

The almost universal adoption of the high-speed petrol-motor as the prime mover in motor road-vehicles at once brought into prominence the importance of devices for enabling the ratio of speed between the prime mover and the road wheels of the vehicle to be varied, by reason of the fact that the speed of maximum torque of a petrol-engine is practically at full power, and as the speed decreases so also does the torque. It may be remarked here in passing that, although the steam-engine, on account of its extreme flexibility, has been, and still is, successfully used in motor road-vehicles—more especially of the heavier class used for commercial purposes—it has been found advantageous even to fit such vehicles with a speed reduction gear to meet the ever-varying exigencies of load and road. In the earlier motor road-vehicles of the renaissance period variable speeds were obtained

* Paper by Robert E. Phillips, member of the Institution of Mechanical Engineers, of London.

either by the use of a plurality of pulley and belt transmissions, or by the use of shaft-to-shaft gearing in which the wheels are engaged by a side movement—that is, in a direction parallel to the axis of the shafts. The former may be said to represent the German school, as instanced by the Benz and the Canstatt-Daimler vehicles, and the latter the French school, as instanced by the Panhard and the Peugeot vehicles.

### Pulley and Belt Transmission Gear.

This is so well known that it is only necessary to state that it has been used with different-sized pulleys, with stepped pulleys, and with coned pulleys. Except for very light motor vehicles, such as motor bicycles and so-called cycle-cars, the use of this type of transmission is a thing of the past.

### Shaft-to-Shaft Gearing.

Although opposed to all mechanical principles, the side meshing type of spur-wheel gearing, in which the various trains of wheels are brought into engagement by "end-on" or clash engagement, has, by the perfection to which its design has been brought, by the high standard of workmanship employed in its manufacture, and by the use of the highest grade of materials, been developed into a completely satisfactory piece of mechanism. Although, from an engineer's point of view, it is theoretically an embodiment of everything that is wrong, in practice it has proved to be "not so bad as it looks on paper," and the fact that it has successfully held its own for nearly twenty years against many other gears which, theoretically, should give better results, is testified to by the fact that at least 90 per cent of the motor road-vehicles at present in use are fitted with this type of gear.

It is, however, only fair to say at once that the position which the sliding type of gear now occupies is due to a very large extent to two factors: (1) that nothing like the same amount of attention has been directed to any other type of gear as has been brought to bear on this particular type, and (2) that the motors now used as of such a high horse-power that at least 75 per cent of the running is now done on the direct drive. Mr. F. W. Lanchester—a Member of this Institution—in his Presidential Address before the Institution of Automobile Engineers, tersely summed up the position of the sliding type of gear in these words: "The sliding type of change-speed gear has ceased to be objectionable to the extent that we have given up using it"—an opinion as true as it is concise.

### Panhard Gear.

In the original gear of this type (Fig. 1), introduced about the year 1894 by the firm of Panhard and Levassor, of Paris, and commonly known as the Panhard gear, all the sliding wheels were mounted on a common element, so that it was necessary to run through the intermediate gears to get from the lowest to the highest gear and *vice versa*, and consequently it is known as the "straight-through" type, in contradistinction to the "selective" type now in almost universal use.

### Renault Gear.

About the year 1890 the firm of Renault Frères introduced a construction of change-speed gear and transmission gear which may justly be said to have revolutionised the design of the transmission mechanism of the modern motor road-vehicle, as at least 90 per cent of the motor road-vehicles driven by internal-combustion engines at present constructed embody one or other of the features of this gear. Instead of transmitting the power from the gear-box to the road wheels by means of a differential countershaft and chain gearing, the road wheels in the Renault system are mounted on a live differential axle which is coupled to the driven shaft of the gear-box by means of a longitudinally arranged shaft, commonly called a propeller shaft.

The Renault gear not only provided for a direct drive between the driving and driven shafts—which is now considered a *sine qua non* in all gears of the sliding type, as it materially reduces both friction and noise—but it also rendered the lay-shafts not only idle but also quiescent during the direct drive. A further advantage of the Renault construction of gear is that the length of the gear-box can be reduced to a minimum, as there is no necessity for any clearance between the different gears, owing to the wheels of the different trains being entirely out of mesh before and when the sliding element forming the clutch coupling is moved. An example of this gear is given at Fig. 2.

#### PANHARD GEAR.

In the early Panhard gear, Fig. 1, the primary or driving shaft V—capable of being coupled to the crankshaft of the motor by means of a friction clutch—and the secondary or driven shaft W are arranged in parallel relation to one another, the secondary or driven shaft being located above the primary or driving shaft. On the shaft V is mounted a sliding sleeve A, which carries four spur-wheels, B, C, D, and E, and on the shaft W are fixed four spur-wheels, F, G, H, and K, with which the sliding wheels B, C, D, and E can be brought into engagement one by one. In the illustration the wheel B is shown in engagement with the wheel F, which gives the first or low speed. On moving the sleeve A to the left, the wheel B is disengaged from the wheel F and the wheel C is brought into engagement with the wheel G, which gives the second speed. Further movement to the left of the sleeve A brings first the wheel D into mesh with the wheel K, thus giving the third and

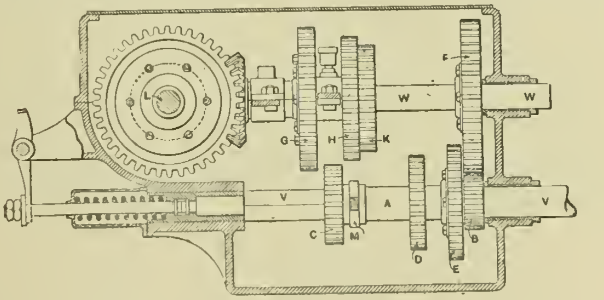



Fig. 1.—Diagram of Panhard Gear.

fourth (or highest) speeds respectively. Motion is transmitted from the driven shaft W to a transversely-arranged differential shaft L by bevel-gearing, the motion of the shaft L being transmitted to the road wheels through chain-gearing. Two bevel-wheels are mounted on the shaft L, each of which is in permanent gear with the bevel-wheel on the driven shaft W, a sliding clutch being provided for coupling one or other of said two bevel-wheels to the shaft L for producing a drive either forwards or backwards.

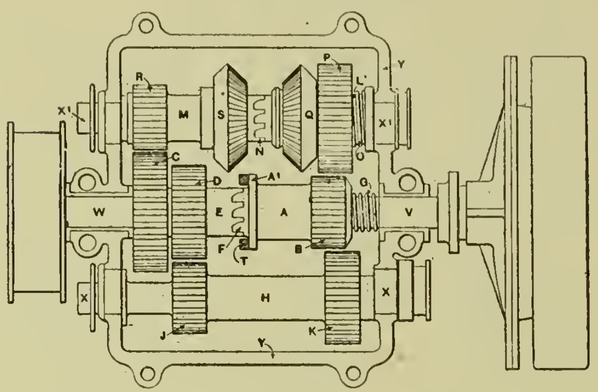
The necessary motion is imparted to the sliding sleeve A by means of a fork M, which engages a groove in the sleeve A, this fork being operated by a pivoted hand lever through suitable connections, the lever being capable of being locked in the requisite positions to keep the various trains of wheels in engagement by trigger mechanism engaging with slots in a suitable quadrant.

#### RENAULT GEAR.

In this gear, Fig. 2, the primary or driving shaft and the secondary or driven shaft are arranged in axial alignment, and a claw-coupling is provided between these shafts so that a direct drive, that is, not through any gearing, can be obtained. The various trains of wheels to effect the gear reductions are brought

into mesh by an eccentric movement of the lay or countershafts after the manner of the back-gear of a lathe. On the driving shaft V is mounted a sliding sleeve A, which carries a spur-pinion B, and on the driven shaft W are fixed two spur-pinions C and D, the latter of which has a sleeve E with which the sleeve A engages by means of a claw-clutch F, which is kept in engagement by the spring G and which is uncoupled by imparting a sliding movement to the sleeve A against the action of the spring G by means of a fork T, which engages a flange $A^1$ on the sleeve A. Located one on each side of the driving and driven shafts V and W are two countershafts X and $X^1$, which

Fig. 2.—*Diagram of Renault Gear.*




are eccentrically mounted in suitable bearings in the casing Y. On the countershaft X is mounted a sleeve H carrying two spur-pinions J and K, and on the countershaft $X^1$ are mounted two sleeves L and M, which are coupled together by a claw-clutch N which is kept in engagement by the spring O. The sleeve L carries a spur-pinion P and bevel-pinion Q, and the other sleeve M carries a spur-pinion R and bevel-pinion S. On rotating one or other of the countershafts X or $X^1$ in a similar manner to the back-gear of a lathe after the clutch F has been disengaged either the pinions J and K can be meshed with the pinions B and D, or the pinions P and R can be meshed with the pinions B and C, thus giving the first or second speeds.

The third or top speed, which is a direct drive, is obtained when the pinions on the countershafts are out of engagement with those on the driving and driven shafts and the clutch F is re-engaged. The reverse is obtained by separating the bevel-pinions Q and S by means of a wedge action and introducing a third bevel-pinion to mesh with these bevel pinions, at the same time uncoupling the clutch F and throwing the pinions P and R into engagement with the pinions B and C.

*(To be continued.)*

# THE TRANSMISSION OF HEAT THROUGH METAL PLATES.

By Edward Ingham.

There are few subjects on which so much misapprehension exists among engineers as that of the transmission of heat through metal plates, tubes, etc. To designers of steam boilers, feed-water heaters, economisers, etc., the subject is indeed of the greatest importance, and unless thoroughly understood, the most efficient designs cannot possibly be obtained.

## The Case of a Steam Boiler.

Consider first the case of a steam boiler. In order to convert the water into steam the heat generated in the furnace has to pass through the boiler plates. A certain resistance to the passage of the heat will, of course, be experienced, and it is the object of the designer to reduce this resistance to within the lowest practicable limits in order to avoid loss of useful heat. Obviously the resistance will depend to a certain extent on the material of which the plates are made, since some materials conduct heat better than others, and also on the thickness of the plates. It is common knowledge that metals are generally amongst the best conductors of heat, and hence, apart from considerations of strength, it would appear that some metal would be the best material for the heating surfaces. As the resistance to the passage of heat through the plates also depends to some extent on the plate thickness, it would also appear that the thickness should be as small as is consistent with safety. Metals such as steel, iron, and copper are of great tensile strength, and comparatively thin plates of these materials are, therefore, generally sufficient to resist the tendency to bursting due to the internal pressure.

## Conductivity of Metal.

Now the views held by so many engineers that it is absolutely necessary the metal used in the construction of boiler plates should possess the highest possible heat conductivity, and that thick plates are quite inadmissible, are scarcely correct. As a matter of fact, both the conductivity of the metal used and the thickness of the plates are quite insignificant factors in comparison with other factors. So far as the transmission of heat is concerned, practically no advantage would be obtained by using copper instead of steel, notwithstanding the fact that copper is a much better conductor of heat than steel, and the use of plates as much as two inches thick would have comparatively insignificant effects in retarding the passage of heat from the hot gases to the water.

## Factors Responsible for Heat Losses.

The factors which are really responsible for losses in the heat transmission are soot, dirt, and non-conducting films of gas on the fire side of the plates, and scale, grease, and non-conducting films of water on the water side. Soot is a very bad conductor of heat, as is evidenced by the fact that it is occasionally used for covering steam pipes with the object of preventing loss of heat by radiation. A thin layer of soot will indeed have a far more serious effect in retarding the passage of heat from the hot gases to the water than would a metal plate of excessive thickness. Similarly, a thin layer of scale will generally retard the heat transmission to a serious extent, because most scales are bad conductors of heat, some much more than others. According to Mr. Stromeyer, the Chief Engineer of the Manchester Steam Users' Association, a layer of average scale one-tenth of an inch in thickness will have as great an effect as will a plate of steel 10 in. thick. Grease is even far worse than scale, in fact a film of grease only $^1/_{100}$ in. thick will, according to the above-named authority, retard the heat flow as much as would a steel plate 10 in. thick.

## Keep the Plates Clean.

It will thus be understood why those plates of a boiler which are exposed to the action of the hot furnace gases should be kept clear of soot and dirt on the fire side and scale and deposit on the water side, if serious loss in the heat transmission is to be avoided. Frequent cleaning is indeed essential to the attainment of high efficiencies in the working of steam boilers.

## Percentage Loss.

One frequently comes across figures given by different authorities to show the percentage loss in efficiency or fuel which results from the presence of accumulations of scale.

The following figures are given by Hutton, and are for average scale:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Scale | $\frac{1}{64}$ | inch thick | causes a loss of | | 2 | per cent | of fuel. |
| " | $\frac{1}{32}$ | " | " | " | 4 | " | " |
| " | $\frac{1}{16}$ | " | " | " | 9 | " | " |
| " | $\frac{1}{8}$ | " | " | " | 18 | " | " |
| " | $\frac{3}{16}$ | " | " | " | 27 | " | " |
| " | $\frac{1}{4}$ | " | " | " | 38 | " | " |
| " | $\frac{3}{8}$ | " | " | " | 48 | " | " |
| " | $\frac{1}{2}$ | " | " | " | 60 | " | " |
| " | $\frac{5}{8}$ | " | " | " | 74 | " | " |
| " | $\frac{3}{4}$ | " | " | " | 90 | " | " |

These figures will serve to show in a general way how serious may be the losses due to heavy accumulations of scale on the plates. It should be understood, however, that much depends on the quality of the scale. A very thin layer of some forms of scale will have a serious effect in retarding the heat transmission, whilst with others considerable thicknesses will have little effect.

From the foregoing we see that the efficiency of the heat transmission will be very much lower if the plates be not kept clean, both on the fire side and the water side, than it otherwise would be. Even with perfectly clean plates, however, it would appear from the results of experiments which have been carried out within recent years, by different authorities, that steam boiler efficiencies are not nearly so high as they ought to be. The reason for this is apparently that on the fire side of the plates there is a stationary non-conducting film of gas, whilst on the water side there is a similar non-conducting film of water.

### Results of Expansion.

In the experiments alluded to the hot gases from the furnace were made to flow over the heating surfaces at high speed, instead of at the usual speeds, and it was then found that the rate of the heat transmission was greatly increased beyond the normal. The obvious reason for this is that the gases, when made to flow at high speed, serve to remove the non-conducting film of gas referred to from off the heating surfaces, the result being that the heat can then pass far more rapidly from the furnace gases to the water in the boiler than it otherwise would do. The same thing will, of course, apply to the water side of the plates.

Now, ever since the earliest days of steam boilers, engineers have held the opinion that when hot gases pass over a metal plate the amount of heat transmitted through the plate will be greater the slower the speed of flow of the gases. This opinion would certainly appear to be supported by common observation and common sense. Thus it seems natural to suppose that the longer the gases remain in contact with the plates the more chance will there be for the latter to extract heat from the gases. This explains why we frequently find designers of steam boilers, feed-water heaters, etc., providing some means for preventing the gases from passing over the heating surfaces too quickly.

As far back as 1874, Professor Osborne Reynolds showed that, contrary to the usual opinion of engineering practitioners, the rate of heat transmission is not reduced by making the hot gases flow faster over the heating surfaces, but is on the other hand very considerably increased.

More recently, Prof. J. T. Nicolson carried out exhaustive experiments which have confirmed conclusively the results arrived at by Reynolds.

### Resistance to Passage of Heat.

As already pointed out, the principal resistance to the passage of the heat through the plates is due to the presence of a stationary film of gas on the fire side of the plates, and a similar film of water on the water side. By making the hot gases and the water in the boiler move rapidly over the plates, these non-conducting films are removed, and the rate of heat transmission is enormously increased in consequence.

To boiler designers, the question of making arrangements for the flue gases and the water to move over the plates rapidly, is obviously worthy of careful consideration, and it may be that it is principally along these lines that higher boiler efficiencies in the future will be obtained. There certainly seems little scope for improvement in other directions, when one considers how much has been done in the way of more economical fuel consumption, prevention of heat losses by radiation, etc.

Prof. Nicolson designed a boiler some years ago, in which special provision was made for forcing the gases at high velocity over the heating surfaces, but the boiler has not proved a commercial success owing to certain practical defects in the design.

The principle of high-speed flow has been used to great advantage in the design of certain feed-water heaters.

A well-known Manchester firm of feed-heater manufacturers carried out experiments which showed that when water is passed over a steam-heated surface at a high velocity, a very much greater quantity of heat is transmitted than is the case when the flow is sluggish. In slow-circulation apparatus, a stagnant film of non-conducting water is always present on the metal surfaces, in consequence of which the efficiency of the apparatus is much lower than it otherwise would be.

The experiments referred to showed that it was possible to obtain a final temperature of water differing but slightly from the temperature of the steam itself. A special design of heater, known as a "high velocity" heater, has therefore been introduced, and it is claimed for this that the feed water may be heated some 20 deg. Fah. higher than is possible with ordinary heaters.

We see, then, that in all cases where it is desired to transmit heat rapidly and effectively through metal plates of boilers, feed heaters, etc., it is necessary that the surfaces should be well scrubbed, as it were, one side with hot gas, and the other with circulating water. The actual thickness of metal and the nature of the metal, *i.e.*, iron, copper, or steel, do not matter very much so far as the heat transmission is concerned.

## CARE AND OPERATION OF ICE MACHINES.*

By Lieut.-Commander J. O. Richardson, U.S. Navy.

### DENSE-AIR MACHINES.

### Principle.

The operation of the machine consists in drawing in air from the system and compressing it to three times its absolute pressure. The work done on the air in compressing it heats it, and it is then passed through the cooling coils, where the circulating water and the cool return air extract the heat of compression before it enters the valve-chest of the expander cylinder. In the expander cylinder the air expands doing work, thereby losing heat, so that it is discharged at a very low temperature—usually about 100 deg. below the temperature at which it entered the expander cylinder, when this is about 60 deg. The number of degrees of reduction of temperature is somewhat greater when the incoming

* Journal of the American Society of Naval Engineer

air is warmer, and somewhat less when its temperature is much below 60 deg.

### Starting.

If the machine is new and is to be started for the first time, it will be necessary to see that the system is clear of sand and scale, as any hard substance in the system will cause endless trouble by cutting the valves, valve-seats, cylinders, and piston packing. The parts of the machine carrying air, and the whole system of piping, should be blown out with air from the ship's air line.

Before starting the machine see that the valves on the suction and discharge lines to the circulating-pump are open, the by-pass valve open, the main valves on the cold air and return air closed, the cylinder drains open, the valves on the hot-air blow line to the expander cylinder closed, and the drain-valves on the expander cylinder and pet-cocks on the traps open. Have all bearings properly lubricated, jack the machine over by hand, and start engine slowly after opening exhaust valve. See that circulating water is being supplied. Close steam-cylinder drains. When the discharge from the drain-valves on the expander and the pet-cocks on the traps is free of oil and moisture, close them, and gradually build up the pressure to 125 lbs. on the compressor. Open the sight-feed lubricators of the compressor and expander cylinder.

When a pressure of 125 lbs. is reached, blow down to 100 lb. through the drain on oil trap and expander drain cocks, and while the machine is building up the pressure open the pet-cocks on the traps and the expander drain-valves at frequent intervals, and at each opening keep them open until the discharge is free of oil and moisture. When the pressure has been built up to about 65 lbs. on the expander and 235 lbs. on the compressor cylinder, cut the machine in on the system by opening the valves on the cold-air and return-air lines, and closing the by-pass valve.

### Speed.

The speed of the machines for every-day service may be anywhere from 60 to 100 revolutions per minute for the two- and three-ton machines, and from 75 to 120 revolutions for the smaller ones. For short periods the larger machines may be run up to 120 revolutions per minute and the smaller ones to 140 revolutions; but the normal speed, if the machine and system are in good condition, should be 60 for the larger machines and 75 for the smaller ones, and if the meat in the cold-storage rooms is well frozen and the temperature can be kept below freezing-point with a slower speed, the machines should be run at as low a speed as practicable.

### Pressures.

Within certain limits the pressure carried has little effect upon the efficiency of the machine so long as the high pressure is approximately three times the low pressure, when these are expressed in absolute pressures. It is the correct ratio of pressures and the circulation of the air in the system which count for efficiency rather than high pressures, so that with a correct pressure ratio low pressures and high speed will give better economy than high pressures and low speed. For customary service, pressures of 65 to 70 lbs. per gauge on low pressure and 230 to 245 lbs. per gauge on high pressure with a moderate speed should be used, but for maximum capacity the pressures should be high and the speed high.

### Cylinder Lubrication.

It is of the utmost importance that the oil used for internal lubrication and for the rods should be the oil that is especially provided for that purpose. It is a good plan to mark the oilcans or distinguish them in some way so that there will be little chance of the oil for bearings being used by mistake for internal lubrication.

For internal lubrication about five or six drops of oil per minute for the compressor cylinder and none for the expander is sufficient, but the manufacturers recommend about three drops of oil per minute for the expander cylinder. It is desirable that the amount of oil used for internal lubrication be reduced to a minimum consistent with satisfactory lubrication, because the oil used is carried over into the system and forms a coating on the inside of the pipes, which reduces their conductivity. On some ships using no oil for the expander cylinder, it has been found advantageous to use a few drops of oil in the primer pump two or three times a day.

### Lubrication of Piston-rods and Valve-stems.

By means of the oil-cups on the piston-rod and valve-stem stuffing-boxes, about two drops of oil per minute should be dropped into the stuffing-boxes; but if the packing of the rods and stems is in good condition and the speed of the machine not over 60 revolutions per minute, no lubrication of the piston-rods and valve stems is necessary, as the oil in the air affords sufficient lubrication. On some ships it is the practice to use the lubricator only on the H.P. piston-rod.

### Lubrication of Bearings.

For lubricating the bearings, about four or five drops of oil per minute is generally used, but the amount used depends upon the condition of the bearings and the speed of the machine.

### Blowing Down.

Once a day it is necessary to clean the machine by heating it up and blowing out all the oil and ice deposits. This is done as follows: While the machine is running slowly and the compressor pressure has dropped to 150 lb., the by-pass valve on the line from the oiltrap to the return-air line is opened, the main valves on the cold-air line and the return-air line are closed, the valve on the hot-air blow line from the compressor to the expander is opened, and then steam is turned on the jacket of the oil trap very slowly and the drain from the jacket opened. Run this way for about thirty minutes, frequently opening the pet-cock on the oil-trap and the drain-valves on the expander so as to remove all the oil and moisture. Then shut off the hot-air blow and the jacket steam, and run the machine on the by-pass until it is certain that the air from the expander cylinder is cold enough; then cut the machine in on the system, closing the by-pass.

In spite of the proper draining of the moisture trap a certain amount of moisture will get into the expander; therefore, it is desirable to open the drain-valves on the expander and the traps about once an hour, and blow out the oil and moisture. On some ships it is the practice to leave the cock on the primer-pump trap slightly open at all times in order to drain the moisture out of the newly supplied air. If the amount of oil used for internal lubrication has been reduced to a minimum, and the drains on the expander and the

oil-trap opened for a few minutes each hour, it is practicable to reduce the blowing-down to once every other day.

### Piston-rod and Valve-stem Packing.

The packing of the piston-rods and valve-stems consists of a few rings of metallic packing, then a hollow oiling ring, then a few turns of L.P. spiral packing. The setting of a definite regular time for repacking piston-rods and valve-stems will prevent troubles and shut-downs; therefore, it is recommended that the metallic packing be examined every two months to see that ends are not butting. At this time the soft packing should be renewed, using L.P. packing, as asbestos packing will score the rods if used in stuffing-boxes of the air cylinders. In replacing this packing it is absolutely necessary to place the oiling ring in the correct position opposite the hole for the oil-pipe, otherwise trouble will be experienced with hot rods and burned packing. The stuffing-box glands should be set up a little more than hand-tight, and great care should be taken to see that excessive friction is not caused by setting up too hard on the e glands. The expander piston-rod should run cool at all times, and if this rod warms up the packing should be overhauled and renewed, if necessary. Leaks around the stuffing-boxes may be discovered by swabbing the rods with oil, and if a very little setting-up on the glands does not stop the leakage it is far better to overhaul and renew the packing than to overload the machine with useless friction and run a chance of heating the rods. On one ship, with an electric-driven three-ton machine, the stuffing-boxes were set up so hard that it required 15 H.P. to run the machine at 60 revolutions per minute with no pressure on the system.

### Packing of Expander and Compressor Pistons.

The pistons of the expander and compressor cylinder are packed with leathers or cast-iron rings. When packed with leathers those in the compressor usually last much longer than those in the expander cylinder. The expander leathers are often cut by ice chips formed in the cylinder, due to the low temperature in this cylinder, but they should last about eight to ten weeks. In overhauling, it is a good plan to turn the expander leathers around so that the same part of the leather is not exposed to the most severe conditions at the cylinder ports. Much time will be saved if a former is used to form new leathers before they are installed, but if this is not used it is a good plan to insert the first new leather in the rear end of the piston, and in a day or two, when this leather is formed, transfer it to the crank end of the piston and put a new leather in the rear end.

All of the late dense-air ice machines have cast-iron rings on both the compressor and expander cylinder.

### Oiling Walls and Expander Cylinder.

The top side of the bore of the expander cylinder will rust very quickly after the machine is shut down; therefore, before shutting down for a long period a little extra oil should be fed into this cylinder. It is good practice to remove the cylinder head and wipe out and oil the cylinder walls, if the machine is to be idle for a week or more.

### Circulating Water.

The constant supply of an adequate amount of cooling water is of vital importance, because the stoppage of the circulating water for only a few minutes while the machine is in operation may result in the scoring of the compressor and expander valves and the burning of the piston leathers.

It is a good plan to have the machine so connected that circulating water may be taken from the flushing system.

### Draining Coils of System.

When the machines have been shut down for some time the cooling coils in the cold rooms will be thawed out, and should be drained of any contained moisture and oil. These coils should not be thawed out or blown out with steam, as it is liable to start leaks, but should be blown out with air from the ship's air lines.

### Cleaning Out the Ice-making Box.

The oil in the cold air will gradually cover the inside surface of the ice-making box and reduce the conductivity of the walls, so that it is good practice to blow out the box with hot air or low-pressure steam when the machine is shut down for some time. Some ships make a practice of boiling out the ice-box when the plant is given a thorough overhaul.

### Washing Out the Cold-storage Rooms.

The cold-storage rooms should be washed out and thoroughly cleaned at least once every three months, as they will soon have a very disagreeable odour, due to the gradual accumulation of blood and small pieces of meat.

### Leaks in Ice Cans.

The ice cans should be frequently examined for leaks, as a small leak will render the ice very disagreeable to the taste.

### Brine.

The brine for the ice-making box is best prepared by filling a bucket half full of crushed chloride of calcium, then filling the bucket with water and dissolving the chemical. Using hot water and stirring the mixture will quicken the process. The solution should be approximately a 20 per cent solution—that is, 20 lb. of chloride of calcium to 80 lb. of water. A stronger solution is unnecessary, as the freezing point of this solution is 5 deg. Fah. The greater the quantity of chloride of calcium in the solution, the lower the specific heat, the less its heat-carrying power, and the greater the tendency to deposit on the walls of the box or in the pipes in brine-circulating systems.

*(To be continued).*

Swedish Engineering Combine.—The Swedish General Electric Co. (Almänna Svenska Elektriska Aktiebolaget) has acquired a controlling interest in the Ljungström Turbine Co. and the Surahammar works. The Surahammar works supply railway material and plant. The Ljungström Co. controls the Ljungström patents for Sweden, Norway, Denmark, Finland, and Russia. A branch factory will be erected in Russia, in order to meet the anticipated demand in that country. The Swedish General Electric Co. is increasing its capital from £1,170,000 to £1,500,000.

# THE MANUFACTURE OF GAUGES AT THE L.C.C. PADDINGTON TECHNICAL INSTITUTE.*

By A. G. Cooke, M.A., W. J. Gow, A.R.C.S., and W. G. Tunnicliffe, Associate Member.

## General Statement.

Although the authors make no affectation of secrecy with regard to the ultimate purpose of the work described in this paper, it will be wise to avoid, not only matters of organisation and finance, but even reference to any other agency concerned, whether authoritative or auxiliary. Nor do they pose as scientific experts, after eighteen months of auxiliary labour, on a matter that reguires a life-time of study. In the standardisation of an engineering industry, vastly exceeding in magnitude any previous human experience, they have been honoured with an important share in practical constructive work, not on account of any recognised merit or skill, but the accident of being the largest Technical Institute maintained by the largest Education Authority.

The Authors deal with workshop details and methods of securing a high degree of mechanical accuracy, under conditions of great urgency and without special equipment. As this work would differ in no particular from that required in the standardisation of any engineering industry of great magnitude, they may hope that an account of their experience may not be without value when another great national effort is required to restock the world with the munitions of civilisation.

This is an Institute devoted to the technical education of the artisan and foreman. The workshop staff is exclusively composed of teachers engaged in the early training of this class, and the pupil assistants are boys representative of the intermediate training. A severe practical test of their efficiency has been made, and their claim is that they have justified the confidence of engineers, even though they may have contributed little that is novel to the science of workshop accuracy.

At the close of the session for evening classes in 1915, the personnel of the Mechanical Engineering Department of the L.C.C. Paddington Technical Institute was reduced to the Head, who, with the Principal, was continuing the engineering teaching of a Junior Technical School of 100 boys (14-16). Of the five permanent teachers of engineering, four had joined the Army and the fifth was "on loan" to a munition factory. From the elementary schools of the Council were transferred two metal-work instructors who had experience in gauge-making, Mr. W. G. Tunnicliffe and Mr. H. C. Christie. Under their immediate direction were placed five other metal-work instructors and sixteen selected woodwork instructors.

Boys of the Junior Technical School in their second year were also employed; the ultimate arrangement adopted being for classes of about seventeen to work every third week for forty-four hours. Experience confirms that this is excellent in results, and worthy of consideration as a permanent system of engineering training.

Machinery that had been in ceaseless use by day and evening students for ten to a dozen years could hardly be expected to be ready for work of the highest accuracy. But no other was available. Practically for all but the "roughing-out" machines complete reconstruction of those essential lathe parts on which precision depends was the first operation.

## Nature of Manufacture.

An explanation is necessary as to the nature of the work undertaken, and its place in relation to the whole industry. The precision desired for primary standards for laboratory testing is limited by practical possibilities only, and the manufacture is not a "commercial proposition." Inspection gauges, or secondary standards, are to be manufactured within a determined though small range of variation or "tolerance." This tolerance should be regarded as a definition, not an error limit. Within the tolerance all values are "correct." In consequence, the manufacture is entirely a question of competitive cost and urgency of delivery.

That standardisation is the key to efficient manufacture and a large output is universally recognised. It is not so well understood that simply on account of the magnitude of the output, apart from the question of excellency of workmanship required, the necessity for standards of a higher order of accuracy arises. It is easy in a small workshop to insure by trial that all fitting is satisfactory; in fact, the initial magnitudes are generally determined by the same tools and standards. In a larger workshop the work is linked by more accurate gauges; and it generally matters little if the absolute measurements vary appreciably from that specified in the design. But when an industry grows to a national or international extent, the standards must aim at specified dimensions of absolute magnitude, defining exactly the limits of permissible variation on either side of the standard, so as to include all acceptable, and reject all unacceptable variations from the correct value. In the language of the calculus, in order to limit variations to a defined "small quantity," inspection gauges are required to be true to the "second order of small quantities." It is just in so far as we can rely on the accuracy of inspection gauges to define the limits of variation permissible, that the designer can allow those limits to be extended with safety. Hence the apparent paradox that high accuracy in the inspection gauges allows more laxity, and so increases facility and speed of manufacture.

## Limit-gauges.

There is no need to describe in detail the principles of limit-gauges for measurements of length and diameters. Both workshop and inspection gauges were manufactured, the essential difference being that the former must be adjusted to be within the specified limits, while any tolerance permissible in the latter must be outside, so as to pass all acceptable work. Tolerance in a workshop gauge tends only to increase the margin of safety, enforcing greater care in manufacture than necessity demands. Uncertainty and variation in inspection gauges is not only unjust to one manufacturer, but affects all by necessitating closer limits.

The necessary order of accuracy for this type of gauge, three ten-thousandths is generally specified, can be obtainted with universal grinders. As the demand was urgent, and grinding machinery not available, they had to resort to handwork. Lapping with high-speed motors up to three or four thousand revolutions, and other devices for acceleration, were developed.

## Position-gauges.

The greater part of the work entrusted to this Institute consisted of a class of gauges determining position

* Read at the meeting of the Institution of Mechanical Engineers on January, 19th 1917.

or some geometrical feature, involving greater difficulties in theory and practice than a single directly measured dimension. Concentricity, perpendicularity, or parallelism, and distance between centres of turning and drilling, are examples. The Authors are unfortunately unable to give details, but it will be seen that to determine some such geometrical condition, or primary measurements, in the work to be tested, limits of accuracy are allowed by a definite variation in the size of diameters of cylinders, pins, or drillings, so as to allow slackness. The gauge limits the combined errors in jig or automatic tool work.

It will be seen that any variation of the inspection gauge, as regards the primary condition, simply displaces the limits which it is intended to give, rejecting satisfactory and accepting unsatisfactory work through a range of double its own error. The practice is to allow a gauge tolerance of only 0·0001 in the primary measurement, and a combined tolerance of 0·0003.

## Screw-gauges.

The methods by which they attained the high accuracy required for screw-gauges are selected for special description. They try to limit any discussion of scientific principles to such as directly affect their work in the construction of the gauges. In screw-gauges the gauging surface is an elaborate skew surface, all parts of which are required to be within the limits, in general fixed at

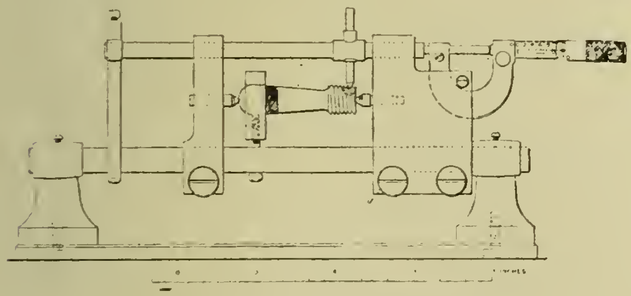


Fig. 1.—Apparatus for Pitch Measurement.

three ten-thousandths measured radially from the axis [0·0006 in diameter]. This means only about $1\frac{1}{2}$ ten-thousandths normally to the slope of the threads. It must not be forgotten that this is the second order of small quantities necessary to define a larger variation permissible in the work. As a variation of which this is 5 per cent would allow a sheet of the "Times" newspaper to be used as packing (three thousandths), it cannot be regarded as too fine.

It should be evident that the accuracy in pitch of the lathe used should be such that no divergency from the correct value greater than about $1\frac{1}{2}$ ten-thousandths should exist throughout the range used. For this would cause a skew surface othewise cut in correct shape to the mean value to pass outside the limits allowed. If any further error in pitch exists, up to an extreme value of three ten-thousandths, it is only possible to keep within limits by thinning of threads, reducing the effective diameter, and the practical difficulties of the reduced margin increase rapidly if the above error is exceeded. The Authors found that the lathes by a number of manufacturers showed an error in pitch of about two in a thousand, always short of specification. This uniform or progressive error is fairly easily corrected by change of gear wheels, as will be shown by an example, but indicates the lamentable need for standardisation in leading screws. Superimposed on this error were periodic errors, initial and produced by wear, requiring measurement, analysis, and correction. It is desirable to repeat that they are aiming not at perfection, but a precision defined by tolerance. In a choice between methods of correction, that which will permanently rectify a discovered cause of variation so as to bring

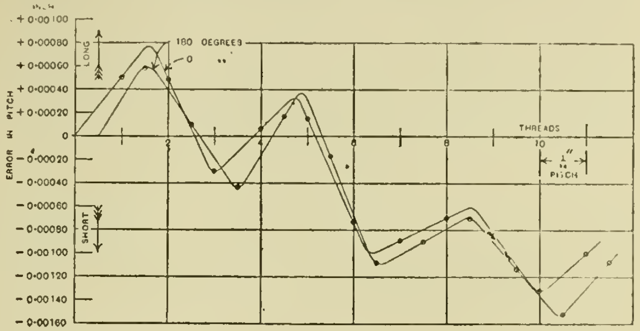



Fig. 2.—Tests Taken on Opposite Sides of a Test-piece of 14 threads to the inch, Leading Screw pitch 4 threads to the inch.

it within the defined limits, is infinitely preferable to any method of compensation which, though more capable of refinement, would allow redevelopment of error in prolonged heavy use, thus delaying output.

The periodic error is amenable to reduction by a final lapping process, but for this not only the amplitude but the length of the periods must be considered, and probably also the method of lapping. Short periods and lapping with high speeds through several turns of the lap seemed necessary to success.

## Workshop Measurements.

It was found absolutely necessary to design and make for themselves instruments by which measurements of pitch and diameters of the screw-gauges could be made on the premises, and optical apparatus by which screw-cutting tools could be shaped and the sections of the screw-threads examined. Details of these may perhaps be of interest, not as examples of high accuracy of physical measurement, but of practical methods suitable to the workshop.

The apparatus for pitch measurement is shown in Fig. 1. By its use on test-pieces they were enabled to analyse step by step the errors of pitch in lathes. One

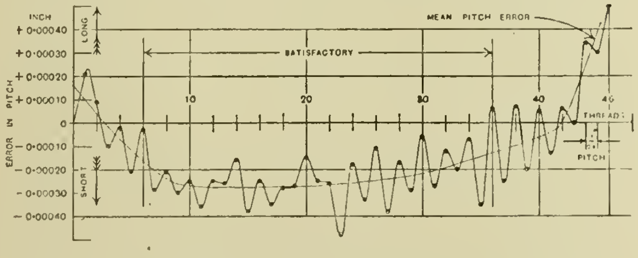



Fig. 3.—Final Test on a Screw showing a Satisfactory Range for a Length of $1\frac{1}{4}$ inches.

example will be given in some detail. The pin, which is moved from groove to groove, followed by micrometer, is turned to a cone of angle slightly less than 55 deg., and the point removed to ensure that the pin touches, not the bottom, but the sides of the groove. Supreme care, by good fitting, is necessary to insure that the points of contact follow a line parallel to the axis of the screw.

The differences between the micrometer readings for each groove, and those calculated for a correct screw of the presumed pitch, are plotted as ordinates in Figs. 2 and 3. These are selected from a large store of records as the first and final pitch diagrams of test-pieces from the same lathe before and after correction. The test of Fig. 3 was taken on opposite sides of a test-piece of fourteen threads to the inch, the leading screw-pitch being presumed four threads to the inch. Analysed, it shows a fairly uniform progressive error of 0·0022 per inch, with superimposed periodic errors corresponding to the revolution of the leading screw, of amplitude 0·0004 inch. The lathe was in good condition, fairly typical of ordinary workshop accuracy.

*(To be continued.)*

## CAST IRON: WITH SPECIAL REFERENCE TO ENGINE CYLINDERS*.

By J. Edgar Hurst.

The trend of advance in connection with modern prime movers, particularly internal-combustion engines, would seem to be in the direction of the improvement of existing types rather than in the introduction of new types of engines. In this connection the materials of construction of the engines occupy no mean share of attention, and cast iron, of which the vitals, the cylinders and pistons of engines, are composed, is by no means of the least importance. The subject, "Cast Iron," has been dealt with many times before, by this and other institutions, and no doubt its importance in this connection is fully realised. It is an undoubted fact that grey cast iron possesses unique and invaluable properties when in use as rubbing parts, and this being the case, one is surprised to find that much is still lacking in the way of actual scientific enquiry into the mechanism of the behaviour of cast iron in this respect.

One or two aspects of the application of cast iron to engine cylinder construction are of great importance, both from a metallurgical and engineering standpoint, and the study of these has engaged the author's attention for some time past. It must be borne in mind, however, that the subjects dealt with are by no means fully exhausted, and an enormous amount of work still remains to be done before these points are thoroughly elucidated and entirely understood.

### The Wearing of Cast Iron.

The wearing and antifrictional properties of cast iron are very intimately related and undoubtedly interdependent; but for the sake of clearness and simplicity it will be advisable to consider them under separate headings. Wear for our purposes may be defined as a mutual loss in weight of two substances when rubbed together over a given period of time. Obviously when the number of substances with which, and the number of modes in which, cast iron can be rubbed, and so bring about wear, is considered, the subject becomes one of exceedingly wide dimensions. Therefore, for the purposes of this paper, it is proposed to consider only the case of wear such as occurs in engine cylinders, that is, wear brought about by the mutual rubbing or abrasion of cast iron by cast iron.

The supreme difficulty experienced in all cases of wear study is the lack of any satisfactory means of reducing industrial conditions to an experimental scale. And doubtless it is to this cause that research in this direction has been so long delayed. Of necessity, therefore, we have to rely for our knowledge of the subject on that chiefly derived from investigations of actual industrial cases—a very slow and prolonged method.

The characteristic feature observed on the visual examination of worn gas engine liner surfaces is that the whole of the worn surface is covered to a more or less extent with small pits or holes. These holes or pits are commonly put down by many engineers to the coarseness of the grain of the cast iron, and are often considered to be the holes from which the coarse plates of free graphite existing in the original iron have been detached. This is not strictly correct, for as a matter of fact on microscopical examination of etched specimens these holes prove to be the result of the detachment of whole grains of any constituent from that particular portion of the surface of the liner. On subjecting worn liner surfaces to a microscopic examination, one invariably finds the harder constituents standing in relief exactly as though the liner had been subjected to relief polishing.

Cast iron, as a whole, is a conglomerate of a number of constituents, ferrite, pearlite, cementite, and phosphide eutectic, of widely different mechanical and physical properties, the soft and ductile ferrite and pearlite on the one hand, and the extremely hard and brittle phosphide eutectic and cementite on the other hand. The whole of the grains constituting the mass are more or less separated by numerous graphite plates, resulting in the mass having a very low inter-crystalline cohesion.

In the engine cylinder, under the influence of the abrading action of the piston rings, together with the slight initial surface disintegration, brought about by the stresses resulting from the reaction of the connecting rod, a certain amount of detached material is produced which becomes powdered and suspended in the film of oil. This suspended material, under the influence of the reciprocating motion of the piston, is undoubtedly responsible for the relief polishing of the surface of the cylinder, resulting in the harder constituents, usually the phosphide eutectic or the cementite, projecting above the surrounding material.

Eventually, these projections, together with the other grains composing the surface of the cylinder, under the influence of the abrading action of the piston rings and the vibratory stresses produced by the motion of the piston and the reaction of the connecting rod, are loosened and subsequently detached, a procedure which is no doubt facilitated by the increased temperatures and gas pressures inside the cylinder. Such is, in all probability, the mechanism of surface disintegration in engine cylinders.

### Surface Flow Phenomena.

It has been well known to engineers for a long period that with cast-iron parts which are subjected to the influence of rubbing actions, such as, for example, engine cylinders, slides, etc., immediately such parts have been in use for a sufficient length of time to have acquired a peculiarly glazed surface or glazed appearance, then satisfactory working of those parts is obtained.

The cylinder walls of high-speed engines, after having been in running for a considerable period, are harder, and become increasingly difficult to file, and the raised markings left on the cylinder walls after a "seizure" has taken place, are often glass hard and incapable of being filed.

* Abstract of paper read before the Manchester Association of Engineers, December 9th, 1916.

The glazy appearance produced on cast-iron liner surfaces after a period of running is undoubtedly very important, and plays a large part in the reduction of the extent of wear, and in the efficiency of its antifrictional properties. Our Continental neighbours would appear to have realised this, and it is believed that some of the large Continental gas engine manufacturers subject their gas engine liners and pistons to a period of running in the engine previous to putting the engine in work. The object of this procedure is undoubtedly to bring about the production of this glazy appearance.

It is very probable that this glazy appearance is the product of a number of different causes. The most important one appears to be that under the influence of alternating stresses brought about by the motion of the piston, the surface grains are deformed by being broken down along the slip planes, ultimately producing a surface of very fine crystal structure. Micro-examination of such surfaces reveals in many instances very finely granular structures even at high magnifications. Such surfaces are harder, and will be obviously far less sensitive to the effects of surface disintegration than the original coarser grained structure. In addition, owing to the increase in the number of crystal boundaries, the total effect of intercrystalline cohesion is enormously increased, and whether this enhanced strength noted at the crystal boundaries is due to the influence of the presence of amorphous cement or surface tension, or both, such superficial layers on liners must be enormously strong. The presence of the elements manganese and chromium in notable quantity undoubtedly increases the resistance of cast iron to wear. This is due to the production of these deformed surface layers, which are readily produced in such irons. Micrographs taken of a gas engine liner surface after a seizure showed a layer of hard matter. The author considers that these layers consist of detached material which has been bodily deposited on the surface of the liner, either from the piston or displaced from some other portion of the liner. In all probability they consist of, in this instance, large ferrite areas which have been detached, and owing to their comparatively large size, and under the influence of the intense pressure, have "flowed" over the surface of the liner. It is very probable that the intense heat developed in this layer, owing to friction (which can actually be It is very probable that the intense heat developed in this layer, owing to friction (which can actually be observed as a white heat), causes the rapid absorption of carbon either from the graphite or from the lubricant, or from both, resulting in the production, at this high temperature, of the hardenite solid solution. The cooling of this highly-heated layer, in actual contact with the solid walls of the liner, is more or less rapid, and, according to the degree of rapidity of the cooling, the type of structure and the degree of hardness presented by the layer is determined. On examination of these layers under the microscope, when etched, structures are revealed which are undoubtedly intermediate between hardenite and pearlite. Similar effects are sometimes obtained during grinding operations on cast iron. Under certain conditions, when the wheel is said to glaze, in the case of cast iron this peculiar hard surface is produced. This is probably the result of surface flow in a like manner to that above.

### Antifrictional Properties.

It is a well-known fact that, apart from the wear of metals or alloys under actual rubbing contact, that certain metals and alloys exhibit a special property of undergoing this rubbing treatment in a more satisfactory manner than others. The extent to which a metal or alloy will undergo this treatment without overheating or seizing, is to a large extent a property of the individual metal or alloy concerned, and this property for the purposes of this paper we designate its antifrictional property. It must be understood that the load, and possibly also the speed under which the mutual rubbing action takes place, also have an influence on this property. For our purposes these influences are at present ignored and considered as constant.

Reference to the so-called antifriction alloys affords an interesting analogy. These alloys are, for the most part, constituted of such metals as tin, lead, copper, and antimony, the proportions of which are so designed as to produce an alloy of such a character as to give the most satisfactory results from the point of view of overheating and seizure when in use as engine or line-shaft bearings.

Exeprience has shown that such an alloy should, as a general rule, consist of at least two constituents of widely different physical properties embedded in each other. When in actual use the surface of such a metal becomes polished in relief, and the harder constituents project above the surrounding matrix, producing a surface of an irregular contour. It is considered that these hard projecting points serve as direct supports for the greater part of the load, whilst the minute hollows serve as minute reservoirs evenly distributing the oil over the whole surface.

In the high-speed engine cylinder the running properties of the material of which the piston and cylinder are constructed are subjects of great importance and demand wide recognition. Primarily it is owing to its special properties in this respect that engine cylinders are constructed of cast iron, and it is very significant that, as yet, we have no other material that will successfully replace cast iron in this capacity. In addition, the limitations of cast iron, both in respect of these properties and also the general mechanical strength properties, are a drawback to advance in high-speed engine design.

The general excellence of the antifrictional properties of cast iron is commonly ascribed to the lubricating qualities of the free carbon content. In a large measure this is quite true, though not *strictly* correct, and, indeed, when it is remembered that cylinder liners and pistons are in successful use for a number of years the influence of the superficial graphite content is not sufficient explanation.

Exactly as is the case with antifriction alloys previously mentioned, under the influence of the reciprocating motion of the piston, and the abrading action of the fine particles suspended in the oil, a surface of irregular contour is developed on the cast iron, the harder constituents standing in relief as illustrated in the section on wear. These minute hollows, together with the holes developed as a result of surface disintegration, serve as distributing reservoirs of the lubricant, ensuring efficacious and excellent distribution of the lubricant over the whole surface. It might also be mentioned at this point that the "glazy" surfaces presented by cast irons after subjection to continuous motion, are also an important consideration in this connection, although at present their influence is somewhat obscure.

*(To be continued.)*

# Trade Items, Notes, &c.

Zinc.—Zinc in commercial quantities was produced in Canada for the first time last year. The smelter at Trail, British Columbia, began operations in March last, and the production until the end of the year was 6,000,000 lbs., valued at £200,000.

We understand that a contract for 125 3½ in. Hyatt Flexible Roller Bearings for line shafting has been received by Messrs. Broom and Wade Ltd., Desboro' Iron Works, High Wycombe, for installation in the new works in course of erection for Messrs. W. Beardmore Ltd., Glasgow.

The Midland Railway Company has 541 stations and 1,934 signal boxes. Its telegraph wires are of a total length of 34,785 miles, the telegraph instruments number 27,792, and telephones 5,940. The number of railway telegrams dispatched yearly is over 8,000,000.

Electric Driving.—The progress made by electric driving in steelworks in America has been remarkable during the last 10 years. For a period of eight years prior to 1914 the number of installations in American steelworks averaged 25 per year, totalling 33,750 H.P., including 300 H.P. motors and larger. During the last two years the number of installations has increased very rapidly, including approximately 125 units, totalling 265,000 H.P., which represents an addition of more than 65 per cent of the drives installed from 1906 to 1914.

Large Aluminium Works.—It is reported that negotiations have been concluded which aim at the establishment in Bavaria of a large aluminium works, with the co-operation of the firm of Giulini, of Ludwigshaven. The undertaking, which will bear the title of the Bavarian Aluminium Works Company, is to produce one-third of the total German consumption, and is to utilise the water powers of the Inn, where plant of 55,000 H.P. will be installed. The expenditure is estimated at £1,500,000, and the work of erection and equipment will occupy two years.

Magnet Manufacture in Sheffield.—One example of the many trades that have sprung up since the outbreak of war is the manufacture of magnets of which Sheffield is now making a speciality. This little industry comprises quite a variety of work, including as it does the relatively small permanent magnets required for magnetos, ships' compasses, etc., and also the powerful electromagnets now coming into wider use for lifting heavy iron articles such as ingots, billets, and castings.

Enemy Trade with Australia.—In a pamphlet recently compiled by the Imperial Trade Correspondent at Perth, Western Australia, it is stated that the value of imports from Germany, Austro-Hungary, and Turkey was £480,801 per annum before the war, the share of each being: Germany, £460,008; Austria, £16,823; and Turkey, £3,970. Among the chief items of imports were electric cables and wires, gelatine, glassware, cotton piece-goods, gloves and hosiery, wire and zinc, cement, cyanide, and pianos. The value of the exports to the three countries was comparatively small, amounting to only about £46,000 per annum.

British Investments and Co-operation.—British investments in foreign public service or utility corporations related to or dependent upon the electrical industry, not including the United States and Canada, are in excess of 1,000,000,000 dollars. The British organisation and control of these undertakings is reflected in the British export trade, for British factories are the chief feeders of these consumers of electrical goods. It is but natural that contract specifications dictated by British executives and engineers call for British or British-standardised equipment and supplies.

Cost of Heating by Electricity.—A number of experiments on various systems of electric heating have recently been reported in the United States. One of the most recent investigations is that of Mr. F. A. Osborn in the *Electrical World* for December 23rd, 1916. The experiment was conducted in a typical dwelling-house on a practical scale, the effects of a standard hot-air system, coal-heated, and a series of electric radiators, in some cases connected with a hot-water heat-storage appliance, being compared. From these tests it is deduced that electricity selling at 0·29 cents (about one-sixth of a penny) per unit would be equivalent to heating by coal with the coal costing 7·75 dollars (approximately 38s. 6d.) per ton.

German Electrical Activity in Switzerland.—It is important to note what Germany is doing in Switzerland. According to the Paris *Journal*, a great number of workshops, employing over 4,000 hands, are busy with munition manufacture on behalf of the Central Powers. Captain Schmitz, Attache to the German Embassy at Berne, is organising the distribution of the work, assisted by the Allgemeine Electricitäts-Gesellschaft, which is itself carrying on operations under cover of a Swiss company of electric appliances—namely, the Prothos Company. This company, which for the past three months has manifested renewed activity out of all proportion to its antecedents, is erecting an important branch factory at Alstetten, near Zurich, for the manufacture of fuses and grenades for the German military authorities.

Magnesite and Products.—The Minister of Munitions gives notice that in exercise of the powers conferred upon him by the Defence of the Realm (Consolidation) Act, 1914, the Defence of the Realm (Amendment) No. 2 Act, 1915, the Defence of the Realm (Consolidation) Regulations, 1914, and all other powers thereunto enabling him, he hereby prohibits as from the date of this Order the use of magnesite and magnesite products for or in connection with (1) the construction or repair of any building (other than a furnace) or any flooring or deck, or (2) the manufacture of any insulating or non-conducting material, except under and in accordance with the terms of a permit granted by the Minister of Munitions. All applications in reference to this Order should be addressed to: Director of Steel Production (W.J.J.342), Armament Buildings, Whitehall Place, S.W.

Agricultural Machinery Controlled.—The Ministry of Munitions announces the formation of an Agricultural Machinery Branch, in conjunction with the Board of Agriculture and the Food Controller. The manufacture of such machinery and implements is classed as munition work. Mr. S. F. Edge has lent his services as Director, and Mr. E. Guy Ridpath has been appointed Deputy Director. An Advisory Committee of representatives of the agricultural machinery trade generally to advise the branch has been established, on which the following have consented to serve:—A. Bornemann (Ruston, Proctor and Co., Lincoln), R. H. Fowler (J. Fowler and Co., Leeds), W. Harrison (Harrison, MacGregor and Co., Leigh), J. Howard (G. and F. Howard, Bedford), E. C. Ransome (Ransomes, Sims and Jefferies, Ipswich), J. Segar (R. Hornsby and Sons, Grantham), with representatives of the Ministry of Munitions, the Board of Agriculture, and the Food Controller.

Monopolies in Certain Lines in Germany.—A special report by Julius G. Lay, United States Consul-General at Berlin, dated November 2nd to 16th, 1915, refers to the electrical industry as follows: In certain lines there are occasionally absolute monopolies. For instance, the Vereinigung Deutscher Starkstrom Kabelfabrikanten is a cartel for high-tension cables. The contract runs until 1917. This cartel is composed of Bergmann, Siemens-Schuckert, Felten and Guilleaume, A.E.G. and Süddeutsche Kabelwerke, and is an absolute monopoly. Also Akkumulatorenfabrik Berlin u. Hagen is a monopoly of the storage battery manufactories. Siemens, Halske and A.E.G. have bought up about 30 different storage battery manufactories, leaving only one outsider, the Accumulatoren und Elektricitäts Werk A.-G., formerly W. A. Böse. The monopoly pays 25 per cent dividends.

The lamp business, which is of great importance, is the main field for sharp competition between the firms A.E.G., Siemens-Schuckert, Bergmann, and the Auer Gesellschaft (which makes only lamps, both gas and electric). However, patent conventions exist between these companies and between each one of them and the General Electric in America. Altogether, there are 11 competitors making metal filament lamps. The German electrical concerns in European countries have their own foreign company; in South America they have their own company in the principal cities, but in some cases have agents to whom salaried engineers from the Home Office are accredited and paid by the Home Office. The A.E.G. alone has 100 offices in Continental Europe outside of Germany and 60 offices outside of Europe.

# New Companies Registered.

AIRCRAFT COMPONENTS AND ACCESSORIES LTD. (145,751).—Private company. Registered January 12th. Capital, £100, £1 shares. Manufacturers and dealers in aircraft parts and accessories, electrical and general engineers, founders, machinists, etc. Directors: A. Spragg and T. Butler. Registered office: 33, Fleet Street, Birmingham.

BRITISH TRANS-OCEANIC CO. LTD. (145,726).—Private company. Registered January 9th. Capital, £20,000, £1 shares. Manufacturers of and dealers in aeroplanes, seaplanes, airships, and the component parts thereof, to acquire, provide, and maintain hangars, garages, sheds, and aerodromes, etc. W. E. Wood is the first director. Qualification, one share. Solicitor: J. R. Cardew Smith, 25, Bedford Row, W.C.

CLEMENT CASTING AND METAL CO. LTD. (145,753).—Private company. Registered January 12th. Capital, £1,000, £1 shares. Manufacturers and founders of copper, copper alloy, brass, gunmetal, phosphor bronze, nickel, spelter, lead, aluminium, iron, steel, gold and silver bullion, and other metal castings and goods, manufacturers of manganese bronze ingots, scrap melters and refiners, etc. R. Place signs as managing director. Qualification, 100 shares. Solicitor: J. Cohen, 11, New Street, Birmingham. Registered office: 14, New Street, Birmingham.

N.S.C. MOTOR AND ENGINEERING CO. LTD. (145,765).—Private company. Registered January 15th. Capital, £5,000, £1 shares. To take over the business of general and motor engineers carried on by J. J. Blackett at Ennessee Works, Park Gate, Darlington, Durham, as the "Northern Side Car and Motor Co." Directors to be appointed by the subscribers. Qualification, £100.

STATON AIRCRAFT LTD. (145,772).—Private company. Registered January 15th. Capital, £20,000, £1 shares (2,000 deferred). Aeroplane engineers, etc. Agreement with J. C. Staton. J. C. Staton is one of the first directors. Solicitor: W. B. Wattson, 18-19, Ironmonger Lane, E.C.

BRITISH-MADE MACHINE TOOLS LTD. (145,706).—Private company. Registered January 5th. Capital, £1,000, £1 shares. Designers and manufacturers of and dealers in machine and other tools of all kinds, engineers, engineering and general agents, etc., in the United Kingdom or elsewhere. C. W. B. Crossley is the first managing director. Qualification, £100. Solicitor: C. Crowther, 23, Abingdon Street, Westminster. Registered by Jordan and Sons, Ltd., 116-117, Chancery Lane, W.C.

ERCOLE MARELLI AND CO. LTD. (145,688).—Private company. Registered January 3rd. Capital, £20,000, £1 shares (preferred). Makers and importers of and dealers in electric and ventilating fans of all kinds, electric dynamos and alternators, direct and alternating-current motors, and dynamos for galvo-plastic industries, etc., and to enter into an agreement with E. Marelli. Directors: E. Marelli, A. S. Benni, and A. M. Baroni. Qualification, £5. Registered office: 19-20, Garlick Hill, E.C.

Aberdeen University.—At a meeting of the University Court recently, the committee on the proposed Chair in Engineering to be established under the bequest of the late Mr. Wm. Jackson, reported that communication had been entered into with the governors of Robert Gordon's Technical College with a view to a joint scheme for the establishment of a department of engineering, and that a meeting had been arranged for an early date.

An Enamel for Iron.—A method of protecting iron by enamelling is as follows: The metal is first pickled in hydrochloric acid to free it from foundry scale, then washed thoroughly and dried. The first coating applied in composed of 34 parts silica, 2 parts soda, and 15 parts borax, mixed in water. The metal thus coated is exposed for from 10 to 15 minutes in a dull-red-hot retort. A second coating is then applied, consisting of 34 parts feldspar, 19 silica, 24 borax, 16 oxide of tin, 4 fluorspar, 9 soda, and 3 saltpetre. This mixture is first melted in a crucible, then ground to a fine paste in a little water, and applied with a brush. The coated piece is then again subjected to white heat in a muffle.

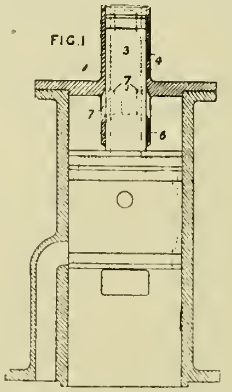
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

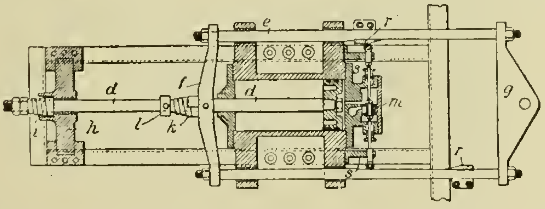
102,006.—J. F. KNIGHT, 60, Valetta Road, Acton Vale, and R. P. DOUDNEY, 92, Prince of Wales' Mansions, Battersea Park, both in London.—March 8th, 1916. Nos. 3,439/16 and 10,078/16.—Engines which compress their pump charges in one end of the cylinder or in a crank casing have each a hollow extension 3 carried by the piston to control the escape of the combustion gases through




exhaust ports 7 in a sleeve 4, 6 at the head of the cylinder. In a modified construction, the hollow extension carries a tube perforated at one end to facilitate cooling the piston. According to the Provisional Specification, the burnt gases escape through ports in the upper end of the tail-rod, and the new charge is admitted to the working cylinder and to the pump through ports in the piston.

### FLUID-PRESSURE ENGINE.

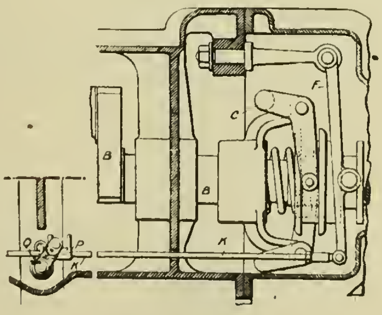
102,027.—W. A. MACHIN, 8, Albert Road, Gravelly Hill, Birmingham, E. MILLS, 9, Harper Street, The Manor, and A. DOWNES, 14, Albion Road, both in Willenhall, Staffordshire.—July 13th, 1916. No. 9,854.—In an engine for jigging conveyors, etc., the valve *m* is moved transversely to the cylinder by longitudinally-moving



tappets *r* on rods *e* connected together by cross-heads *f*, *g*. The cross-head *f* is arranged between a shoulder on the rod *d* and a spring *k* held in position by a collar *l* secured to the rod *d*. The valve spindle is provided with external guides *s*, and the piston-rod *d* is provided with an outer spring *i* which makes contact with a stationary bearing *h*.

### SPEED GOVERNORS.

102,121.—ALBION MOTOR CAR CO. and T. B. MURRAY, South Street, Scotstoun, Renfrewshire.—July 3rd, 1916. No. 9,293.—In an internal-combustion engine, a governor C is mounted on the end of the crank-shaft B in the crank case, and its muff is connected by a



lever F to a member K longitudinally movable in the crank case. The crank K has a lost-motion connection with a lever P fixed to a vertical shaft Q, which is connected to a throttle valve in the induction pipe, and passes through a hollow pillar between the crank case and the induction pipe.

## STEAM-GENERATORS.

102,029.—R. Shenton, 60, Sydney Road, Tilbury Dock, London.—July 19th, 1916. No. 10,164.—Longitudinal stay bolts 1 in a Cornish or like boiler are supported by plates 5 secured to the shell and flues, the end plates 3 are strengthened by plates 13

FIG. 2.

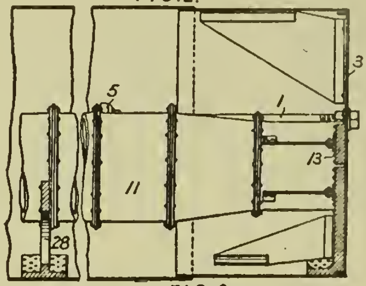
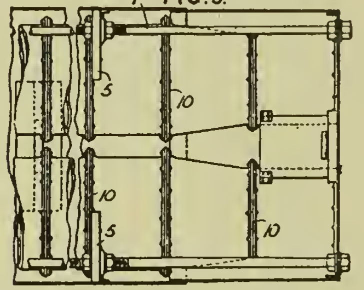


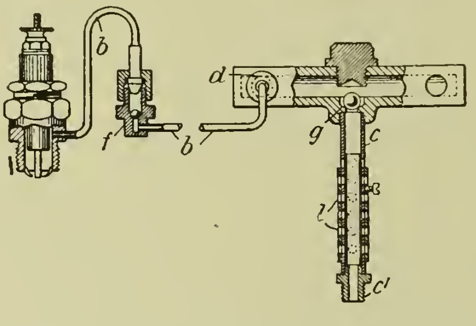

FIG. 3.




riveted to their inner surfaces, and the flues 11 are supported on brackets 28 secured to the bottom of the shell. The plates 5 are ribbed and are secured to the shell by angle-irons. The plates are bolted at their inner edges to the flue flanges 10. The plates 13 are stayed to the shell and flues.

## SPARKING PLUGS.

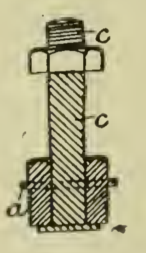
102,128.—A. E. Lamkin, 86, Springfield Road, Brighton, Sussex.—July 21st, 1916. No. 10,297. Addition to 102,222.—For the purpose of cleaning and cooling the terminals, carburetted air enters the combustion chamber on the suction stroke by means of a pipe *b*, non-return valve *f*, and, if necessary, a distributor. The dis-




tributor may consist of a **T**-shaped tube connected to the induction pipe by a union *c*1, and to the pipes leading to the plugs by unions *d*, a non-return valve *g* being inserted. The tube *c* is perforated and enclosed in a rotatable perforated tube *l* whereby air may be admitted.

## BOLTING STUFFING-BOX GLANDS, ETC.

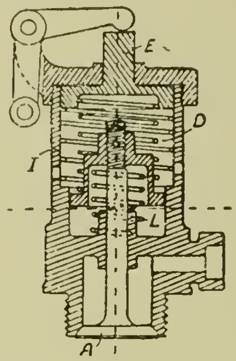
102,179.—T. J. Lewis, Fair Oak, Argoed, Monmouthshire.—Feb. 1st, 1916. Nos. 1,531 and 9,238.—Relates to means for adjustably securing the glands in stuffing-boxes, etc., and consists in holding the gland in position by a bolt *c* mounted in a plug *a* screwed



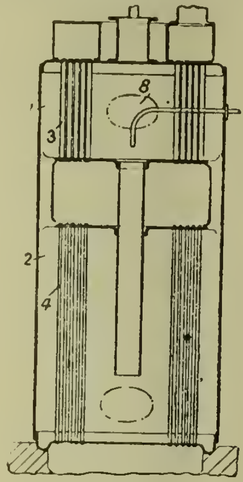

into the stuffing-box wall or flange. The hole in the plug may be square, triangular, or of other polygonal shape; or it may be round, in which case the bolt is prevented from turning by projections thereon engaging recesses in the plug.

## INTERNAL-COMBUSTION ENGINES.

102,185.—J. Martin, 1020, Argyle Street, Glasgow.—February 14th, 1916. No. 2,143.—A compression relief valve A is opened by a spring D compressed to any desired mechanism. The weight of the plunger is supported by a spring I, a further spring L holding the valve in its closed position. The valve opens automatically, and closes when the compression reaches a determined value. By depressing the plunger until it engages the valve stem, the valve may be held in its open position until released by its actuating-mechanism. The spring L may be dispensed with.




Patent 102,185.




Patent 102,194.

## STEAM GENERATORS.

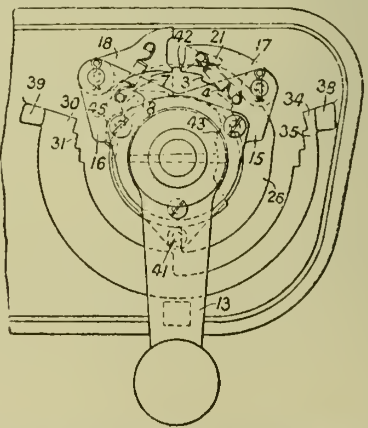
102,194.—W. Anderson, Inistore, Helensburgh, Dumbartonshire, and J. Meikle, 14, Garrioch Drive, Maryhill, Glasgow.—March 4th, 1916. No. 3,280.—In a boiler consisting of superposed drums 1, 2 traversed by stacks of vertical smoke tubes 3, 4, the tubes are so disposed as to permit of lateral access to all the tubes in each stack. The tubes are preferably so arranged that radial gaps are left in the stacks opposite the manholes 8.

## INTERNAL-COMBUSTION ENGINES.

102,186.—G. E. Bradshaw, A.B.C. Works, Hersham, Walton-on-Thames.—Feb. 15th, 1916. No. 2,219.—The ribs on air-cooled cylinders are turned out of the solid from a bar or tube of steel and are then electro-plated with copper or some other good conductor.

## RATCHET GEARING.

102,195.—W. B. Bennitt, Ivybank, Moss Lane, Ashton-on-Mersey, Cheshire.—March 4th, 1916. No. 3,293.—A shaft for operating electric motor controllers, circular dial switches, etc., is rotated in a series of steps by ratchet gearing, stops being provided to prevent rotation beyond definite positions which are different for each tooth of the ratchet, so that the position of the operating handle will show through how many steps the shaft has been

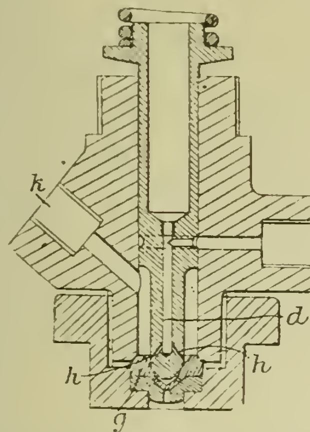



rotated. Fig. 1 shows an arrangement with two pawls and sets of teeth for rotating the shaft in either direction. The pawls 17, 18 are carried by the handle 13, and the teeth 3, 4, 7, 8 by the shaft to be rotated. The teeth in each set are placed in succession nearer to the axis of rotation. On moving the handle 13 to the left, the pawl 18 engages the outermost tooth 42 and rotates the shaft until a projection on the pawl meets a fixed stop 34. The handle is then retracted until the pawl engages the next tooth 7. A fixed cam 43 engaged by a projection on the back of the pawl prevents the engagement of any other tooth in the series. On again moving the handle to the left, the pawl 18, being nearer the axis of the shaft, misses the stop 34 and engages the stop 35, rotating the shaft through another step. Subsequent steps are effected in a similar manner. During these

movements, the pawl 17 is held out of contact with the teeth 3, 4 by a fixed cam 26 engaged by a projection 21. Similar cams and stops 45, 30, 31 enable the shaft to be rotated in the opposite direction by the pawl 17. The shaft is returned to its zero position by shoulders 15, 16 moved by the handle to engage a projection 41 on the plate carrying the ratchet teeth. Stops 38, 39 limit the movement of the handle.

## INTERNAL-COMBUSTION ENGINES.

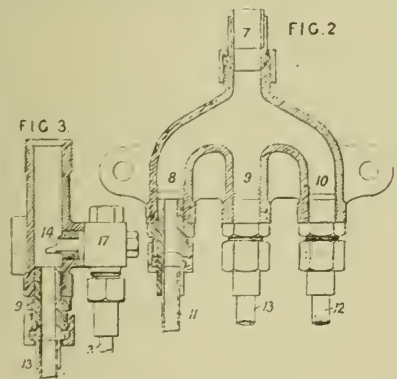
102,200.—E. GARDNER, Barton Hall Engine Works, Patricroft, Lancashire.—March 14th, 1916. No. 3,794. Nozzles that deliver two kinds of fuel are so constructed that the fuel for starting ignition enters the valve-chest nearer to the valve seating than the




main fuel. In the nozzle shown, which is similar to that described in Specification 1680/13, the main fuel enters at *k* and the lighter fuel through the passage *d* and branches *h* in the valve spindle which open near the seating *g*.

## LUBRICATING LOCOMOTIVES, ETC.

102,202.—T. C. THOMSEN, Danebo, Bencombe Road, Purley.—March 15th, 1916. No. 3,856.—Locomotives and other engines are lubricated by a mechanical or force-feed lubricator, which supplies oil directly to the piston-rods, axle-boxes, etc., and also supplies oil to atomisers in feed-pipes, whence it is carried by steam to the valves and cylinders. In the form shown the feed-pipes 11, 12, 13 for supplying lubricant to the valve-chests and cylinders are directly connected to a steam-supply pipe 7 connected with the dome of the boiler and each branch 8, 9, 10 is provided with an



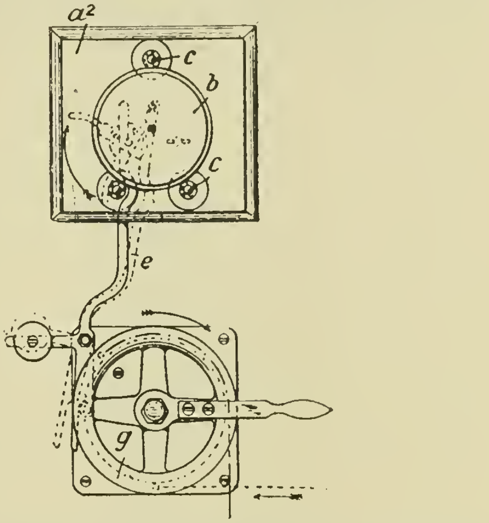

atomiser such as 14, Fig. 2, to supply oil to the passing steam. The atomisers 14 are preferably of the spoon type, which presents a film of oil to the passing steam, and oil is supplied to them by the lubricator through pipes 3 and check valves 17. A "choke" of known form is preferably fitted into each feed-pipe beyond the atomiser, to prevent excessive flow of steam and ensure that all the steam shall be brought into contact with oil. The steam-pipe 7 is provided with a valve controlled by the driver.

## CASE-HARDENING.

102,205.—L. C. MUNN, Titton Cottage, Stourport, Worcestershire.—March 24th, 1916. No. 4,365.—A material for case-hardening comprises charcoal or other carbonaceous material in or on which barium carbonate, or a salt which becomes converted into barium carbonate in use, has been formed or precipitated. The material may be made by treating the charcoal, etc., with a solution of barium hydrate and converting the hydrate into carbonate by the action of carbon dioxide or gases containing carbon dioxide, for example, by feeding the treated charcoal through a tower through which the gas is passed in the opposite direction; or the charcoal may be impregnated with a solution of barium carbonate in water containing carbon dioxide under pressure, and the excess carbon dioxide driven off by heat; or the charcoal may be treated with a solution of a barium salt and then with a solution of a carbonate; or a solution of an organic salt may be employed which is converted into carbonate in use. In some cases, crude mineral oil may be added to the mixture.

## FURNACES.

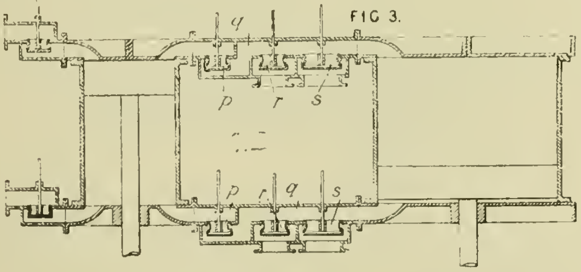
102,211.—S. SAUNDERS, 43, Lower Mosley Street, Manchester.—April 29th, 1916. No. 6,154. For automatically quickening up the banked-up boiler fires of heating-installations in lock-up floors, small warehouses, etc., where it is undesirable for an attendant to enter the premises outside the ordinary working hours, an alarm clock is arranged to operate a mechanical release so as to open the draught door and damper, to bring into action a blowing device or fan, or to turn on a supply of gas or liquid fuel at a predetermined time. The alarm clock *b* is enclosed in a suitable case *a*2, into which projects the end of a weighed lever *e*, the

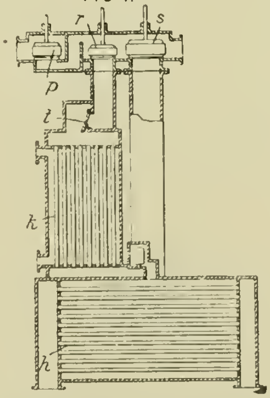



other end of which serves as a detent to hold a chain-wheel *g*. A weighted chain or other flexible connection wound on the wheel *g* is connected to the damper, door, or valve. At the required time, a pin on a lever connected to the alarm spindle of the clock pushes aside the lever and releases the chain-wheel. As shown, the clock is attached to pins or spindles *c*, over which slide bored brackets on the clock case; but it may be attached to the hinged door of the casing *a*2 or otherwise mounted. The chain may act on the lever of an automatic regulator in connection with the boiler.

## STEAM ENGINES.

102,217.—H. DAVEY, Conaways, Ewell, Surrey.—May 15th, 1916. No. 6,933.—In a compound condensing engine, steam is supplied to a feedwater-heater from the low-pressure cylinder before the



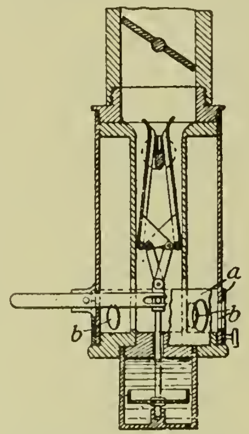




end of the power stroke. In the construction shown in Fig. 3, the high-pressure cylinder exhaust valves *p* serve as admission valves to the low-pressure cylinders. On the pipes *g* connecting the two cylinders are two valves *r* which communicate with the

feedwater-heater $k$ arranged above the condenser $h$. A non-return flat valve $t$ is arranged between the valves $r$ and the heater $k$. The valves $r$ open at about seven-eighths of the stroke. The low-pressure exhaust valves $s$, which lead to the condenser, open just before the end of the stroke and remain open for about one-eighth of the exhaust stroke, when compression begins. In a modification, flat slide low-pressure exhaust valves are used.

### INTERNAL-COMBUSTION ENGINES.

102,218.—W. G. LITTLE, Buckingham House, Shoreham, Sussex.—May 25th, 1916. No. 7,451.—In carburettors wherein the passage around the nozzle is controlled by a pair of spring-loaded suction actuated flaps, means are provided for varying the admission of air to the carburettor. The invention, although applicable

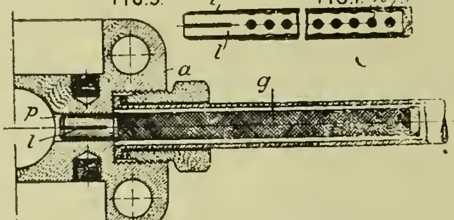



to other types of carburettor having the pair of flaps, is shown as applied to the carburettor described in Specification 11,887/15, and consists of a ring $a$ with apertures $b$, the ring being adjustable angularly through a distance equal to the diameter of an aperture.

### INTERNAL-COMBUSTION ENGINES.

102,219.—W. H. MOORE and A. SHARDLOW & CO., Ealing Works, Sheffield.—May 30th, 1916. No. 7,636.—A filter for liquid fuel is placed as close to the atomiser nozzle as is possible, and comprises a cylinder of gauze surrounding and supported by a perforated metallic tube. The supporting tube $t$, Fig. 1, is made from a length of round steel or other suitable metal and is

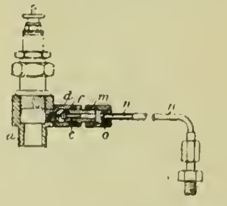
FIG. 3. FIG. 1.




perforated with holes $h$. A piece of tubing may be used, in which case one end must be plugged. A layer of gauze $g$ is placed over the tube and is secured by a coil of wire or by soldering. The open end of the tube is formed with slits $l$ to enable it to be sprung into the hole $p$, Fig. 3, in the atomiser body $a$. To increase the effective area of the gauze, the holes $h$ may be connected by grooves turned in the wall of the tube $t$.

### SPARKING-PLUGS.

102,222.—A. E. LAMKIN, 86, Springfield Road, Brighton, Sussex.—June 15th, 1916. No. 8,470.—For cleaning and cooling the terminals, a sparking-plug is mounted in a socket $a$ having a lateral opening, through which air or mixture may be drawn.




A spring-pressed valve $f$ has its seating in a flanged tube $e$ screwing within a tubular projection $d$ from the wall of the socket $a$. A cap $m$ screws over the other end of the tube $e$, the closed end of the cap being holed for the passage of a tube $n$, the end of which is provided with a ball valve $o$.

# INDEX TO ADVERTISERS.



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# Industrial Engineer.

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## The Industrial Engineer.

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CONTENTS.



# EDITORIAL.

## REFORM OF OUR COINAGE AND WEIGHTS AND MEASURES.

During the progress of this great European War, we in this country have set about a self-examination into our methods of manufacture and into the conduct of business generally, and with our usual British spirit have, in a general sense, cried ourselves down, sometimes so much as to apparently deserve the epithet applied to us by our German enemies of being "a decadent nation." Of course, the epithet is not really deserved, as we hope to convince the Germans, to their undoing, before long. Nay, we are rather inclined to think that the convincing has already come about, if we may take note of the flattering attentions which are being increasingly bestowed upon us by the Hun, particularly during the past eight months or so. For it is becoming increasingly evident that the Hun considers us to be his most implacable foe, notwithstanding the brilliance of the achievements of our gallant and brave Allies. The Hun may at least lay this flattering unction to his soul, that his diabolical attempt to impose his military will, not only on Europe but upon nations over the distant seas, has at least assisted us to discover ourselves afresh. The truth had been gradually struggling towards the light for many years prior to this dreadful upheaval, for we had begun to set our house successfully in order in many directions. Our accomplishments in a warlike direction, in the short period of a war for which, in a military sense, at least, we were totally unprepared, have even gained the admiration of some Germans, whilst admitting they may be somewhat uncomfortable to themselves and destructive to that equanimity of mind with which they entered into the conflict in its early stages. The average Britisher, of course, has still got the obsession that we always "muddle through somehow," and that this was and still remains a truly British characteristic; but, bless your soul, at the bottom he begins to be just a little proud of our collective accomplishments, and never for one moment tolerate the evidence in his mental make-up of the possibility of failure. He quite pleasantly ignores the fact that in the matter of great manufactures there are still many lines in which his country stands pre-eminent, and is likely to give both the Huns and many others a great run for their money before he is, if ever, ousted from the leading place.

### The Necessity for Change.

Now the foregoing characteristics of the average Britisher are just those which prevent him seeing that his country's present system of coinage and his tables of weights and measures are not what they might or ought to be. He has at least just got that same kind of trait which he deplores in the Hun in this present war, of desiring to force his system of coinage and avoirdupois upon the world at large—only in a kindly way—and to pit his skill against his foreign competitors by measuring him in inches and feet. One cannot altogether blame him, for he has been brought up under the system from childhood and youth, to middle-age and beyond, until the system has become part and parcel of his nature, what time he has been cajoled into playing at political forms of Government instead of seeing that business propositions are the only politics that become a country seeking to maintain commercial supremacy. During this time also the trade of the country in general has not suffered that serious diminution, as the result of competition, as to make him really sit up and take notice. But let us make no mistake, he is beginning to sit up

and think real hard. His sporting instinct, which the Hun has seen fit to deride, will still be of great service even in the direction of reforming his system of coinage and weights and measures, for it will make him see that if we, as a nation, are to take away a good proportion of enemy trade and direct it to our own mills and workshops, it will have to be done in such a way as will make it easier for our customers to understand. Orders mostly follow the line of least resistance, and it seems only a commonplace to suggest that we should adopt a system of coinage and of weights and measures more in consonance with the practices of the great bulk of nations with whom we trade or wish to trade. Self-interest alone ought to make us grasp that simple fact, without the necessity of lengthy argument. And in spite of all the arguments to the contrary, there is, to our mind, no question whatever as to the rightness of a decimal system of coinage and a metric system of weights and measures. True, there would be some trouble in the transition, but it would not be comparable to the trouble of translating and transmuting the Hun out of Belgium and France, and not a tithe so costly in money and no cost in lives, except to the die-hards who are always against the adoption of new and sane methods of business, but who, fortunately, are beginning to be a negligible quantity.

### A New Manchester Association.

We have a great deal to gain by the change suggested, and for that reason we welcome the inauguration of the Manchester and District Decimal Association, one of many kindred associations throughout the country, whose special object is to further the question of a decimal coinage and a metric system of weights and measures. The Manchester Association begins with the happiest auguries for success, inasmuch as it already possesses on its membership roll some of the most eminent men in the textile and engineering trades of the district, other names equally well known in merchant and shipping circles, and the heads of all the leading educational institutions of the city. With such a body of supporters, the movement cannot fail, but, like other bodies wedded to other reforms, its work can be made lighter and its task correspondingly easier by the adherence of others who believe in the objects the Association is formed to attain. To this end, we commend our readers' attention to the work, and ask them to communicate with the acting secretary, Mr. Fred Hilton, 55, Market Street, Manchester.

## THE INTERNAL-COMBUSTION ENGINE.

By Dugald Clerk, D.Sc., F.R.S., M.Inst.C.E.

*(Continued from page 166.)*

The stationary internal-combustion engine industry grew very rapidly in England, and, as will be seen from the figures already given, the German industry in 1907 was smaller than the English industry, and just before the war it is believed that the proportion of industrial engine work in England and Germany was practically the same as in 1907. An impression has grown in this country that Germany was more advanced in the application of internal-combustion power than we are here. This is due to the fact that the Germans have devoted much more attention to the large-cylinder gas engine and oil engine than the British. English engineers have never been satisfied with the existing line of development of these large-cylinder engines. From the scientific point of view they consider that the building of large engines practically without modifications of either thermodynamic or operative cycle was a costly mistake leading to development in a wrong direction. Accordingly in England more attention has been given to multi-cylinder engines than in Germany, the idea being to keep the dimensions of the cylinders as small as possible. By so doing, engines were produced of a greater power for a given weight of metal utilised. British engineers and scientific men are still convinced that other methods must be found of increasing power in internal-combustion engines than mere increase of dimensions of cylinders and massive construction of engine parts as practised in Germany. Undoubtedly a solution will be found which combines high powers with small weights. So far as stationary engines are concerned, cylinder for cylinder, the internal-combustion engine is at a disadvantage in weight for power compared to the steam engines without their boilers. A very large industry has been created in small cylinder engines, but the power unit attained as yet is not sufficiently great to compete with the larger steam engines, especially in the form of steam turbines. Notwithstanding the fact that English makers mainly confine themselves to smaller cylinder engines, it is a mistake to assume, as is too often done, that the Germans are in advance of us in this line of work, either in practice, industry or science. While in Germany engineers paid great attention to larger cylinder engines, England was busy developing the smaller types adapted to use heavier oils, such as kerosene and paraffin. The first engine to attain success as a kerosene or paraffin engine was produced by Messrs. Priestman, of Hull, in 1885. Mr. Stuart Akroyd, in his patents of 1886 and 1888, described an engine which, in the hands of Messrs. Hornsby, has taken a most important position. In that engine, air alone is taken into the cylinder of an internal-combustion engine through an inlet valve, and the combustion chamber is kept separate from the inflowing air by the device of using a chamber of bottle-neck construction, the bottle-neck opening into the cylinder. This bottle-neck combustion chamber is only partially water-jacketed, and one part of its surface can in the first instance be raised to a low red heat by means of a pressure lamp. The oil to be used is pumped into this combustion space during the suction stroke of the engine, but little or no mixture occurs until compression begins. The compression of the air by the piston on the return stroke forces the air charge to mix with the vaporised oil existing in the combustion space mixed with products of the previous ignition. The temperature of the hot wall is so adjusted that when compression is complete or nearly complete the mixture ignites and a moderate explosion pressure is produced. This type of engine is very successful, and is made in large numbers throughout the world. Other methods of operating internal-combustion engines have been experimented upon in this country by many inventors and manufacturers.

One set of experiments made by me possesses special interest. The experiments were made at Messrs. Tangyes' works in Birmingham at the end of 1887 and the beginning of 1888. In this engine the cylinder was charged with air on the two-stroke method which I have already described. The air was compressed into a space at the end of the cylinder, and coal gas was compressed by a separate pump. When the motor piston completed the compression of air, the gas pump forced a jet of compressed gas into the compressed air, and an igniting device was so arranged that this jet ignited as it entered the compressed air. No gas was added to the air until compression was complete. The diagrams produced by this engine closely resemble those

of the steam engine—a rise at the beginning of the stroke, constant pressure for a certain forward part of the stroke, then cut-off and expansion. The engine, in fact, was as I called it at the time, a flame-injection engine, in which explosion was avoided altogether. This engine ran for six months and many tests were made. The explosion engine was held to have certain advantages which prevented this particular type from being put upon the market. Its interest arises from the fact that it was, I believe, the first engine operated by the injection of a flame jet into compressed air within a cylinder. Five years later Dr. Diesel, the distinguished German inventor, began work on an engine in which he compressed air through a range of about twelve. Compressing air to one-twelfth of its former volume sufficiently rapidly, raises the temperature of the air to about 600 deg. Cen. Dr. Diesel then injected fine oil spray into this highly-compressed hot air. The spray at once ignited, and a diagram very similar to the early Clerk diagram was produced, but at a much higher pressure with greater expansion, and therefore much greater economy.

Dr. Diesel was an able engineer of great pertinacity, and he succeeded in working through the great difficulties of this type of engine. It has, as we all know, become a most important feature of internal-combustion work. The Diesel type engines, with their high compression and automatic ignition, used for the first time very heavy oils in a most effective way. The Diesel engine undoubtedly fulfils important purposes in both stationary and marine work where oil can be had. Although it has taken an important place, and will continue to occupy an honourable position, its advocates have rather exaggerated its possibilities. The amount of oil in existence in the world is too small to allow of the future proposed by Diesel enthusiasts. For stationary purposes undoubtedly gaseous fuel prepared from coal or carbonaceous matter will maintain the leading position.

An interesting paper was read by Dr. Diesel at the Institution of Mechanical Engineers in the beginning of 1912, and in the discussion which followed, Diesel most honourably admitted the advantages he himself had derived in producing his engine from the study of earlier English work. Dr. Diesel's fate was a sad one. He worked with the utmost faithfulness and pertinacity from the initiation of his experiments in 1887 until his untimely death in 1913. He was lost, as you will remember, from the steamer "Dresden," on a passage between Antwerp and Harwich on September 29th, 1913. Notwithstanding his strenuous and useful work he died in great monetary difficulties. The period of existence of his patent in Germany and England was insufficient to enable him to reap any reward for his persevering technical efforts. This has proved the fate of many inventors, and the more important the invention the more likely is it that the term of the patent expires before commercial success is attained. Great departures are made with difficulty, while small changes are easily and rapidly applied. In the early stages of the Diesel engine the inventor was under the impression that he could produce a motor which followed the Carnot cycle in its entirety. Such an engine requires compression to the full temperature necessary for the addition of heat, expansion for a certain distance at constant temperature, and then further expansion to the lowest temperature, the heat discharged being obtained by compression at the lowest temperature. Such a cycle of operations gives the maximum possible efficiency between certain heat limits. Diesel misapprehended the position, and he failed at first to see that the mean pressure obtained in such a cycle was very low compared to the maximum pressure necessary. Thus, with a maximum pressure of 500 lbs. per square inch the mean pressure was only 6 lbs. per square inch. Such an engine would be, under the assumption, a perfect thermodynamic machine; but unfortunately it would give no power—friction would be too great. Accordingly, the claim made by the supporters of Diesel in its early stages to a superior thermodynamic cycle from that of ordinary explosion compression gas engines falls to the ground. As a matter of fact the Diesel cycle has a smaller efficiency for a given compression than the explosion cycle.

Had coal gas been the only fuel possible for internal-combustion engines it could not have attained its position of to-day. In providing other gases for this purpose England also led the way. Mr. J. E. Dowson, in 1881, constructed a gas producer, using anthracite, which operated by passing a mixture of steam and air over incandescent anthracite. The gases leaving this apparatus contained hydrogen, carbonic oxide, some carbonic acid, nitrogen, and a little oxygen; and when cooled evolved on combustion about 160 B.Th.U. per cubic foot.

The pressure gas producer which he first exhibited, operated a Crossley gas engine in the year 1881 at the York meeting of the British Association. The invention of the Dowson pressure producer extended the sphere of these engines in a very material way, and led to the construction of what are called suction producers, operated without steam boilers or pressure blowers. Such producers have been applied very extensively in Britain and all over the world in units of from about 20 to 500 H.P. The suction modification was operated at first in France by the well-known engineer, Benier, in 1894, and the French development was continued in England and in Germany about eight years later.

England, too, led in the use of bituminous fuel producers; the late Dr. Ludwig Mond, of Brunner, Mond and Co., devoted much time and effort to the production of large plants capable of gasifying bituminous fuels. In the larger plants Dr. Mond included devices for the chemical recovery of ammonia and the production of sulphate of ammonia. This work of Mond's has been most important, and many large installations of gas engines are now in operation up to about 3,000 H.P. using gas from Mond plant.

An English inventor, the late Mr. B. H. Thwaite, in 1895 made an important experiment in the application of the waste blastfurnace gas to the purpose of power production. His first plants were installed at the Glasgow Iron Works and at Barrow-in-Furness, and the idea was soon taken up at the great Belgian works of Messrs. Cockerill. There the large cylinder gas engine was first developed. About 1900 an engine of 51 in. cylinder diameter was exhibited as applied to blowing for blastfurnaces. This engine was the result of the work of M. Delamare Deboutteville. This was the beginning of the large cylinder movement on the Continent. It was taken up in Germany by the Deutz Works, Cologne, and by the Oechelhauser Co. America followed, and in England, too, several makers devoted considerable attention to the large cylinder engines. The large cylinder movement has, however, undoubtedly prospered more on the Continent and in America than in this country. The extent of the trade, however, is not very great compared to the trade in small cylinder engines; and it is to be hoped that the efforts of British and other engineers will be successful in producing more powerful engines of less weight and bulk. The present large cylinder engine solution is by no means satisfactory, either to the engineer or to the scientific man.

The leading names in German invention and design are thus Otto, Daimler, Diesel, Oechelhauser, and Koerting.

British work in this line was accomplished by Crossley, Clerk, Robson, Atkinson, Humphrey, Priestman, Stuart Akroyd, Hornsby, Dowson, Mond, and Thwaite.

The four-stroke Otto engine, it will be seen, was adopted in England by Messrs. Crossley, and the two-stroke engines of Clerk and Robson were adopted in Germany by Koerting and Oechelhauser.

Of the German inventors, Otto is by far the most important. Daimler's merit consisted in his appreciation of the fact that a four-stroke engine of small dimensions could be safely run at a high speed of rotation; and his little petrol motors, from their relatively light weight and high power, were rapidly adapted by Germans, French and Belgians to the purpose of motor-car propulsion. England, unfortunately, was hampered by an absurd law which required mechanically-propelled vehicles to be preceded on the road by a man carrying a red flag. This red flag Act was not repealed until 1896, so that after that date Britain rapidly gained headway in the construction of the very small cylinder petrol engine, and by its designers and scientific investigators shared fully in the modern development of the motor-car and the aeroplane. The aeroplane became practicable by the genius of the brothers Wilbur and Orville Wright in the United States in the year 1906. They were the first successfully to apply a petrol engine to a mechanical glider. America and France led the way with the aeroplane and the modifications of engine required for aeroplanes until 1909, when the Government Advisory Committee on Aeronautics was started, and the same year saw the beginning of the Royal Aircraft Factory. Another body, the National Physical Laboratory, in conjunction with these two institutions, made numerous experiments on the different factors required in flight. The co-operation of the three bodies in conjunction with the manufacturers of Britain resulted in the highly successful British aeroplane of to-day.

The industry devoted to stationary gas engines, oil engines, and petrol motors in Britain is now very large. An indication of the relative development in England and Germany is given by the comparison, by a well-known Belgian consulting engineer. Mr. R. E. Mathot, of the production of the Gasmotoren Fabric Deutz and its licensees in Germany with the production of Messrs. Crossley Bros. Ltd., of Manchester, up to the year 1909. The German firm up to the end of that year had completed altogether 410,098 H.P. of stationary gas engines. The English firm had built 1,020,230 H.P., and this formed but a small part of the output of Britain. From this it must be evident to you that, acting in our own independent manner, Britain has accomplished a large share of the work of the development of the modern internal-combustion engine, both in design, construction, commercial manufacture and development of scientific knowledge. In some fields more work has been done in Germany, in others more in Britain.

*(To be continued).*

Proposed Plant Extension.—The Electricity Committee of Burton-on-Trent has decided to approve a scheme of extensions at the electricity works. Application is to be made to the L.G.B. and the Treasury for sanction to borrow £25,000 for the plant, etc., required. During January, 127,803 units were sold for lighting, power, heating, etc., and 50,977 for traction, showing an increase of 93,651 units under the former head, and a decrease of 1,096 units for traction as compared with January of last year.

## VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.

*(Continued from page 168.)*

### Daimler Gear.

The advance that has been made in the side meshing type of gearing will best be realised by comparing the original Panhard gearing, Fig. 1, with an up-to-date gearing as exemplified in the modern Daimler gear, which is described in Fig. 3.

The Daimler gear embodies two important features not to be found in the Panhard construction, namely, the placing of the driving and driven shafts of the gear in axial alignment, and the employment of more than one sliding element. The first of these two features enables the driving and driven shafts to be connected together by a direct couple, so that a through or direct drive from the engine to the transmission gearing can be obtained; and the other feature enables any desired gear to be obtained without running through any other gear. This type, which is known as the "selective" type, has entirely superseded the "straight-through" type, as it not only reduces wear and tear on the teeth of the wheels, but enables the over-all length of the gear-box to be materially shortened, which stiffens the shafts, and by removing the tendency to whip, which throws the gears out of pitch, not only materially increases the mechanical efficiency of the gear, but also reduces noise. The junction of the driving and the driven shafts, and the spur-wheels permanently gearing the driving shaft with the lay or countershaft are arranged at the front end of the gear-box, and the sliding element is mounted on the driven shaft. This allows the countershaft to be geared down in relation to the driving shaft, with the result that when the driving shaft is coupled direct to the driven shaft to obtain the direct or through drive, the countershaft and the wheels on it are rotating at a minimum speed. This was at one time thought to be of considerable importance, not only on account of the reduction of friction set up by the revolving parts, but also on account of the power lost by the churning up of the oil or grease in the box; but latterly, since the introduction of anti-friction bearings for the shafts and the use of thin oil as a lubricant, the opposite construction, in which the junction of the two shafts and the train of wheels permanently gearing one of said shafts to the countershaft are arranged at the back end of the box, has been adopted in order to reduce the noise to a minimum when the car is at a standstill with the engine running and the clutch between the engine and the gear-box is left in engagement, which is the usual condition of things when a car is making a temporary stop. Under these conditions the countershaft and all the wheels on it, together with the wheel on the driven shaft which drives the countershaft, are at a state of rest.

From a comparison of the two types of gear illustrated in Figs. 1 and 2, it will also be observed that each has an advantage over the other with a corresponding disadvantage. In the former the power on all the speeds is transmitted through one pair of gear-wheels, so that the frictional losses due to the gearing are the same on each speed, while in the latter type the power on one speed is direct, that is without going through any gearing, but on the other speeds the power is transmitted through two pairs of gear-wheels, so that on all speeds other than the direct one there is twice as much frictional loss as in the type of gear illustrated by Fig. 1. This naturally directs attention to the fact that the direct

drive should give the ratio of speed between the engine and road wheels best suited to each particular vehicle and the work it is called upon to perform. The general practice is to give the direct drive on the top or highest speed, and this is probably the best all-round practice for gears which give only three forward speeds; but when four forward speeds are provided the direct drive is sometimes on the third speed, the fourth speed—which in this case is a geared-up one—being only intended to be used under the most favourably running conditions.

The use of a plurality of sliding elements necessitates the use of a particular form of controlling mechanism as each change of gear involves two distinct movements, one to pick up the particular rod controlling the sliding element giving the desired gear, and the other to impart the necessary movement to said controlling rod. This is effected by giving to the control lever two movements, first a lateral one in line with the axis of its pivot, and secondly a rocking one at right angles to said axis. This involves the use of a guide for the control lever having two longitudinal slots and a transverse connecting slot, hence the appellation "gate change" usually associated with this mechanism. This was first introduced into this country on the German Daimler cars known as the Mercedes, in the form shown in Figs. 4, 5, and 6, which is for a gear-box having three forward speeds and a reverse which are controlled by two sliding elements, one of which gives the top and second speed, and the other the first speed and the reverse.

## Prevention of Wear on Teeth.

The prevention of undue wear and tear on the teeth of the wheels, due to the clash engagement, has been the desideratum of all designers of this type of gear, and the problem has been tackled in many different ways. The earliest method adopted was to keep the various trains of wheels constantly in mesh, one wheel of each train being loosely mounted on its shaft, and to provide independent sliding claw clutches for completing the driving couples between the wheels and their shafts. This construction had the defect that it seriously increased the over-all length of the box and thereby increased both its weight and the cost of production. In a modification of this construction internal coupling devices were employed, but while these did not increase the length of the box, they involved considerable complication. In another system the wheels on the countershaft were loosely mounted on said shaft, and an automatic driving couple was provided between each wheel and the shaft by means of a one-way clutch, so that the shaft could over-run the gear wheels, but said wheels could not over-run the shaft. The complications involved in this system were quite sufficient to condemn it.

## Weller Gear.

According to another system the sliding wheels are mounted loosely on their shafts, and are brought into mesh with the respective corresponding wheels of their trains before they become coupled to the shaft on which they are mounted. Such a gear is the Weller, Fig. 7. As this gear is probably as cheap, if not cheaper, to make than the usual pattern of this type of gear, owing to the absence of a square or splined shaft and a similar sliding element, it is difficult to understand why it has not been more universally adopted, as it undoubtedly affords considerable protection to the teeth of the wheels from damage by careless or untimed changing, and consequently would not only wear longer, but would make for sweetness and quietness of running and ease of manipulation.

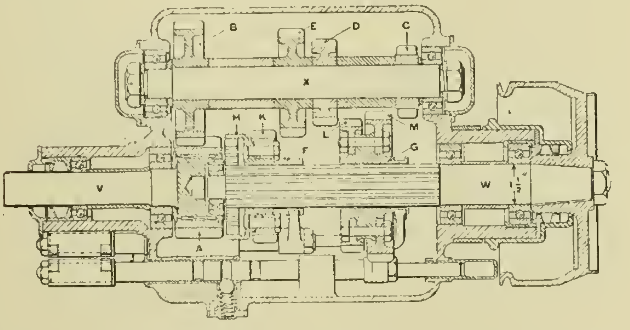
## Dux Gear.

Further development along this line of construction brings us to the Dux gear, Fig. 8. In this gear the wheels of all the trains producing the forward speeds are in constant mesh, and the sliding wheels themselves form parts of positive clutches, the other parts taking the form of internal toothed rings. This construction enables the box to be kept very short, and produces a very compact and robust gear, but it appears to be open to the objection that at all speeds all the wheels are running. This gear-box is fitted to the Caledon commercial vehicle in this country, and has been exclusively adopted by the Paris General Omnibus Company for their public service vehicles.

### MODERN DAIMLER GEAR.

In this gear, Fig. 3, the front end of the driven shaft W is journalled in the rear end of the driving shaft V, on which is fixed the permanent driving spur-pinion A, which is in constant mesh with a spur-pinion B on the countershaft X. This countershaft also carries other spur-pinions C, D, and E. The driven shaft W is splined, and on it are mounted two sliding sleeves F and G, the former carrying both an internally-toothed wheel H and a spur-pinion K. The internally-toothed wheel

Fig. 3.—*Modern Daimler Gear.*




H by engaging with the pinion A forms a direct-driving couple between the driving shaft V and the driven shaft W, and gives the fourth or top speed, and the spur-pinion K by engaging with the pinion E on the countershaft forms the driving connection between said countershaft and the driven shaft to give the third speed. The sleeve G also carries two spur-pinions L and M, the former adapted to mesh with the pinion D on the countershaft to give the second speed, and the latter adapted to mesh with the pinion C on said countershaft to give the first or lowest speed.

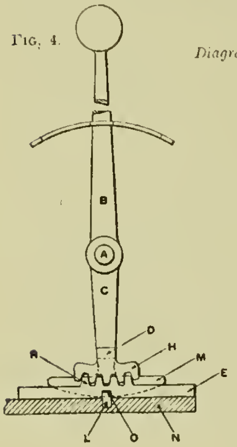
### MERCEDES CONTROL.

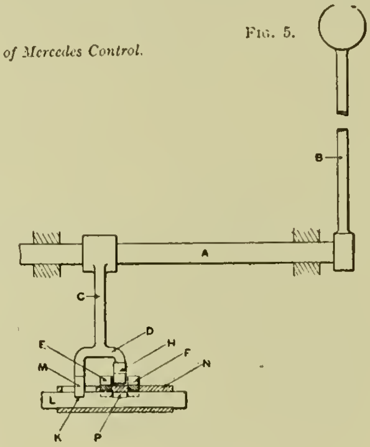
In this control, Figs. 4, 5, and 6, a shaft A is so mounted as to be capable of having both a fore and aft rocking movement and a transverse sliding movement imparted to it by the hand-lever B. This shaft carries a selector arm C, which terminates in a fork D, one element of which engages one or other of the rods E and F through a toothed quadrant H and a rack R, and the other element of which engages a slot K in a locking key or bolt L through a plain quadrant M. The rods E and F, which engage the sliding elements of the gear by means of the usual forks, are mounted to slide in a suitable guide N, in which the locking key or bolt L is mounted and arranged to slide. The plain quadrant M, by reason of its permanent engagement with the slot K in the key or bolt L, is free to move in respect of this key or bolt when the shaft A is rocked, and to impart a corresponding relative movement to this key or bolt when the shaft A is moved axially. In the underside of each of the rods E and F is a slot O with which the key or bolt L engages, and in this key or bolt is a second slot P, which will allow either of the rods E or F to pass across it when they are brought into line with it by the transverse movement of the selector arm C. It will be seen that, by imparting an axial movement to the shaft A, the toothed quadrant can be moved out of its central position—in which it can have no rocking movement by reason of its engagement with the central bar of the "gate" guide—and can be engaged with one or other of the controlling rods E and F, at which time the slot P in the key

or bolt L is so positioned as to allow the rod with which the toothed quadrant is engaged to slide in its bearing—through the key L—on motion being imparted to it by the toothed quadrant H by reason of the rocking motion imparted to the shaft A. The gate R for this mechanism is illustrated in Fig. 6, the hand-lever B being shown in its central position, in which position as shown in Fig. 5, the toothed quadrant H is out of engagement with either of the rods E and F, and these rods are positively locked against movement by the key or bolt L. If the hand-lever is moved into one or other of the slots of the gate the selector arm becomes engaged with one or other of the controlling rods, and on a fore or aft movement being imparted to the hand-lever, the sliding sleeve in the gear-box is moved in one or other direction to engage one or other of two trains of wheels. When there are four speeds and a reverse, the two sliding elements give the top and third speeds and the second and first speeds respectively, and the reverse is obtained either by means of a separate sliding element with an independent pick-up, or by running through the first speed.

Instead of using a positive lock for the controlling rods, automatic spring-controlled catches are often employed. A common form is a small sphere held up by a spring and adapted

Fig. 4. *Diagram of Mercedes Control.* Fig. 5.





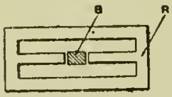


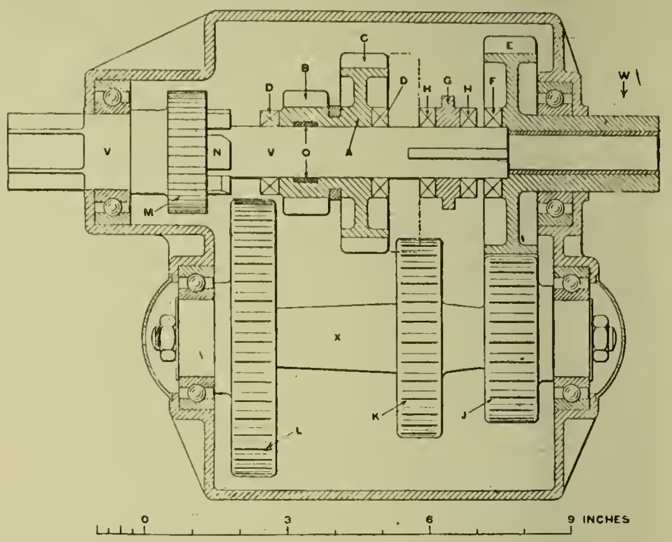
Fig. 6.

to engage with grooves turned in the controlling rod. Such a device is shown in the illustration of the Daimler gear-box, Fig. 3. The most up-to-date practice is to mount the gear-changing mechanism on the gear-box instead of on the frame of the vehicle, so as to avoid the possibility of any binding taking place due to distortion of the frame.

## WELLER GEAR.

In this gear, Fig. 7, a sleeve A carrying two spur-pinions B and C, and having claws D at each end, is mounted on the driving shaft V so that it is free both to slide and rotate thereon. On the driven shaft W, which is hollow and fits over the end of the driving shaft, is fixed a spur-pinion E having claws F on its inner side. On the shaft V is also mounted a sleeve G, which is free to slide thereon, but which has no independent rotary movement. This sleeve is provided with claws H at each end, whereby it can be coupled either to the sleeve A carrying the spur-pinions B and C by means of the claws D and H, or to the spur-pinion E on the driven shaft by means of the claws F and H. On the countershaft X are fixed three spur-pistons J, K, and L, the former of which is in constant mesh with the pinion E on the driven shaft. On the driving shaft is a fixed spur-pinion M for the reverse, which is provided on its end opposite the sleeve A with claws N adapted to engage with the claws D on the adjacent end of said sleeve. If the sleeve G is moved to the right until it engages the spur-pinion E, the driven shaft is coupled to the driving shaft, thereby giving a direct through drive, which is the top gear. If the sliding sleeve A is moved to the right after the sleeve G has withdrawn from engagement with the pinion E, the pinion C first becomes meshed with the pinion K on the countershaft, and subsequently becomes engaged with the sleeve G, the effect of which is to couple the pinion C to the driving shaft and give the second speed through the wheels C, K, J, and E. The dot-and-dash line shows how the pinion C is engaged with the pinion K before it engages with the sleeve G, thus ensuring the safety of the teeth of the pinions at the moment of the couple of the pinion C with the driving shaft. If the sleeve A is moved to

Fig. 7.—*Weller Gear.*




the left the pinion B first engages the pinion L on the countershaft, and subsequently becomes coupled to the driving shaft by the engagement of the sleeve A with the pinion M. Within the boss of the sleeve A is a friction ring O, the function of which is to cause the sleeve to rotate with the shaft when the sleeve is in its central or free position, whereby the wear between the sleeve and the shaft is reduced to a minimum, as the only movement between these two parts is at the moment of engagement of the first and second speed trains. The reverse is obtained by bringing an intermediate pinion mounted on an independent shaft—not shown in the illustration—into engagement with both the pinion M and the pinion L when the sleeve A is in its central or free position.

## DUX GEAR.

In this gear, Fig. 8, a spur-pinion A is so mounted in the driving shaft V as to have free relative rotary movement thereon, and is in constant mesh with a spur-pinion B, fixed on

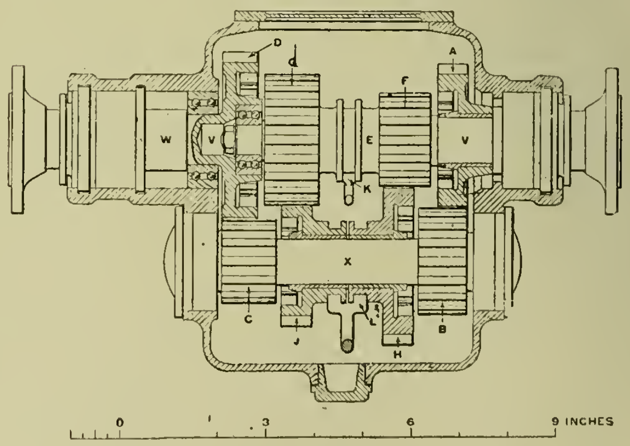



Fig. 8.—Dux Gear.

one end of the countershaft X. On the other end of the countershaft is fixed a spur-pinion C, which is in constant mesh with a spur-pinion D, fixed on the driven shaft W. On the driving shaft, which is splined to receive it, is a sliding sleeve E, which carries two spur-pinions F and G, and on the countershaft are, loosely mounted, two spur-pinions H and J, the former of

which is in constant mesh with the pinion F, and the latter in constant wesh with the pinion G. Each of the pinions A and D has an internal ring of teeth with which the teeth of the pinions F and G respectively engage when the sleeve E is moved to the right or left, and each of the pinions H and J has an internal ring of teeth which engages with the teeth of the pinions B and C respectively when the pinions are moved to the right or to the left. Motion is imparted to the sleeve E by means of the usual fork K, and motion is imparted to the two pinions H and J by a fork L, which engages the bosses of both of these pinions, so that, although the pinions have free relative rotary movement, they are constrained to move together axially.

The top or direct drive is obtained by engaging the pinion G with the internal teeth of the pinion D, thereby locking the driving shaft to the driven shaft. The third speed is obtained by sliding the sleeve E until the pinion F engages the internal teeth of the pinion A, so that the drive is transmitted through F—A, B, C, and D. The second speed is obtained by sliding the two pinions H and J until the internal teeth of the pinion J engage the pinion C, so that the drive is transmitted through G, J, C, and D. The first speed is obtained by sliding the two pinions H and J until the internal teeth of the pinion H engage the pinion B, so that the drive is transmitted through F, H—B, C, and D. The reverse is obtained by sliding a double gear—not shown in the illustration—into mesh with the pinions D and H.

*(To be continued.)*

# THE EVILS OF "MAKESHIFT" IN THE POWER-HOUSE.

By F. R. Parsons.

## Makeshift Methods.

A policy of "makeshift" might be an adoption meeting with some favour, and fraught with little consequence in some industrial concerns or departments, but in the power-house, the fountain from whence springs all productive activity, it should be a condition least of all to be tolerated. Yet one must confess that "makeshift" methods are as much the rule as the exception, and it is only in very few power-houses that a condition of things exist in which the practice is not only discountenanced, but by reason of duplicating and change-over facilities is rendered more or less unnecessary.

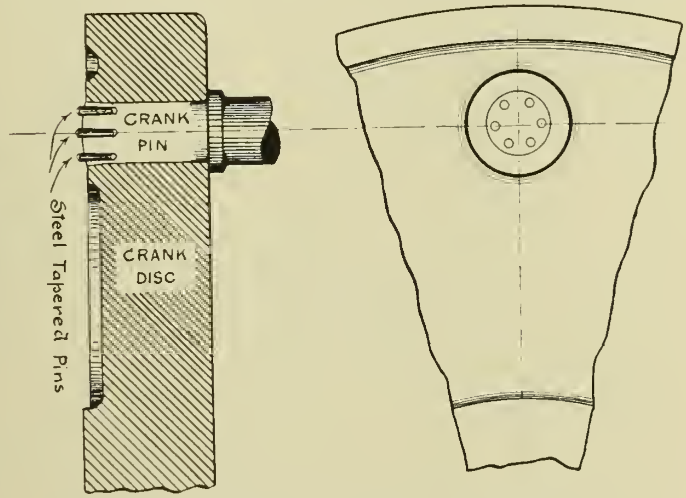
If one with experience in these matters were asked to define the meaning of the word "makeshift," as applied to power-house maintenance and mechanical problems therein encountered, he would be perfectly justified in giving it as a temporary repair executed in a great hurry, but which, by reason of its success in attaining its end, becomes a permanency. And this, it might be said, typifies to a great extent a very large number of instances whereby the truth of this can be borne out by fact.

## Some Instances.

One or two of such the present writer can cite. Quite 30 years ago, when serving his apprenticeship, he, with others, was called in to execute a hurried repair upon the beam of an old-type vertical table engine installed in a flour mill. The repair in question was necessitated by the fracturing of the beam near the parallel-motion end, this being caused by the end of a steel joist breaking away from its hoisting tackle on the floor above, where it was being set in position, and coming end down on to the beam of the engine. It meant a week-end job, and was accomplished by studding on two steel-joint plates, one on either side of the beam; these being fitted singly inside the webbed section. The engineer in charge was, it is remembered, not altogther enamoured of the repair, even though the subsequent running of the engine was in no way impaired, and accordingly put in hand the production of a pattern wherewith to cast a new beam, and have fitted ready for any emergency. By the time the pattern was ready, however, this individual must have formed quite an altered opinion, for he caused the completed pattern to be carefully stored away until some future time, when it appeared more likely than then to be needed. Some twelve months ago, the writer was on a visit to his native town, and, incidentally, this particular mill. Chance took him past the building wherein he remembered the pattern to have been stored. He looked, and it was still there. Inquiries revealed the fact that it had never once been removed, or used, and the steel-patched beam is still doing duty on the engine to this day. And the engineer who was in charge is sleeping with his fathers.

## Another Instance.

Now for another instance, having a different ending. Some four or five years ago the writer was called in to advise upon a defective crank-pin of a 150 H.P. condensing horizontal engine, driving woodworking and sawing machinery in a mill. The pin, about 7 in. long in the journal, by $5\frac{1}{2}$ in. diameter, was tapered and riveted into the disc. This, for some time on and off, had given signs of being loose in the hole, and occasioned a bad knock; its looseness and consequent wear being indicated, upon




Evils of "Makeshift" in the Power-House.—Fig. 1.

examination, by the fact that a steel feeler, 0·012 in. in thickness, would penetrate easily to the fuel depth of the instrument between one side of the pin and the whole. As a temporary measure only the writer recommended drilling into the riveted end of the pin, quite close to its outer diameter, a series of $\frac{1}{2}$ in. dia. holes, and driving hard therein six slightly-tapered steel pins, as in Fig. 1; this with the object of expanding the end of the crank-pin, and so tightening it in the hole. At the same time he also recommended that a new crank-pin should be put in hand to replace at the very first convenient opportunity the worn one. This was done, and the writer, after being assured that the "makeshift" repair was effectively fulfilling its purpose, left things to take their due course. Some three years later, however, he got to hear that a bad smash-up had occurred to this engine. The "temporary" repair had proved such a success that the new pin had never been put in, and one day the old one had given out quite unexpectedly, with the result that it came out of the disc, crippled the connecting rod, smashed the front-end cylinder cover, fractured the crosshead and two of the slide bars, and generally played havoc with the engine. So much so, in fact, that at

considerable expense and loss of time, a new and more modern type engine had to be installed.

### A Turbine Job.

On another occasion the writer was called in to advise what should be done with a 100 H.P. turbine, driving a paper mill. This had become loose on its foundations, these being of oak beams built into masonry forming the turbine chamber. He advised the removal of the old wood supports, and the substitution of rolled steel joists; meanwhile to wedge up the turbine framing with hard wood wedges until such time as the conversion could be undertaken. The temporary recommendation was adopted, the steel joists prepared and drilled to take the turbine bed, but the actual conversion was deferred time and again, as the "makeshift" was still satisfactory. Then with the usual unexpectedness the climax came. It gave out one night, just as the mill was in the middle of an important contract that was taxing its productive capacity to the utmost. The turbine got away from its foundations, twisted off the main shaft, smashed the reduction gear, and fell through its supports to the bottom of the chamber. The mill was silent for the better part of a fortnight until the necessary reconstruction could be accomplished.

### General Conclusions.

Sufficient should now have been said to disprove the truth of the theory that a "makeshift" repair, if temporarily successful, should in a general way be accepted as fulfilling indefinitely the purpose intended to be served by a repair upon which much time and thought and preparation had been expended in order to replace, as nearly as possible, conditions which obtained previous to the breakdown. At the very best a "makeshift" repair should be regarded only as a temporary measure, since invariably no attempt is made to provide for results other than of the most temporary character, and in order to get over a difficulty with the least possible delay. On the other hand, a well-executed repair, over which time and trouble has been taken, in the execution of which ample time is allowed, is invariably productive of good results, and a feeling of permanent security and satisfaction. This alone should make it wholly worth while going to the expense of the repair: for a shoddy job, accomplished in a hurry, and with little or no facilities to hand, must, however secure it looks at the moment, be a never-ending source of anxiety and dread to the far-seeing and prudent engineer-in-charge.

## CAST IRON: WITH SPECIAL REFERENCE TO ENGINE CYLINDERS.

By J. Edgar Hurst.

(*Continued from page 175.*)

### Micro-Structure: Influence and Considerations.

It will readily be seen in this connection that the micro-structure of cast iron is of prime importance. In the first place, it will be evident that up to a certain point, as a result of the wearing action on cast iron, a surface possessing good antifrictional properties is produced. Even in cast irons containing no well-defined hard constituents, such as, say, for example, phosphide eutectic, the effect of surface disintegration will result in the production of surfaces having good antifrictional properties. Obviously, however, excessive wear as a means of obtaining efficient liner surfaces is highly undesirable from the point of view of engine power development, and in addition the excessive production of débris resulting from surface disintegration, more particularly in the initial stages of the running of liners, is a contributory cause to "galling or seizure."

The cast iron having the highest intercrystalline cohesion, otherwise the highest tensile strength, will possess the greatest resistance to surface disintegration, and, consequently, to wear. Under a given load and speed, therefore, it would appear that wear in engine cylinders is proportional to the tensile strength of the iron. This conclusion was arrived at by Messrs. Ludwig Loewe and Co. Ltd., from a series of experiments in which the wear was determined as the loss in weight after rubbing cast-iron cylinders for a given length of time, under a given load and speed, on a hardened steel die.

Cast iron of the highest tensile strength at normal temperature is that having the closest grained structure and a free carbon constituent existing in a very finely divided, or alternatively, in a rosette form.* Generally speaking, in so far as the tensile strength of cast iron is concerned, the identity of micro-constituents is of little importance providing the above conditions obtain. Consequently it would appear that the corollary of this statement is true, and that the identity of the constituents is of little moment in the case of wear.

In so far as pure surface disintegration is concerned, and under ideal conditions, this would appear to be perfectly true. The effect, however, of the action of alternating stresses on the character of the surface grains, and the effects of the differential polishing of these grains largely modify this conclusion, and in this respect the identity of the constituents is of importance.

It is yet too early to state definitely the influence of different constituents on the production of "glazy" surfaces. The greater portion of our knowledge and experimenting in this direction is confined to the behaviour of pure metals only, and its extension to, perhaps, the most complex of all alloys, cast iron, involves an enormous amount of work.

The extent of the differential polishing of the surface grains in a large measure depends upon the individual characteristics of the grains. It will be obvious that this effect in excess will rapidly lead to the inauguration of surface disintegration. Cast irons constituted of large grains, varying widely in physical hardness, are an example of this type of occurrence, and the comparatively rapid wearing of coarse-grained irons, consisting largely of ferrite and phosphide eutectic, is in a large measure due to this cause.

The influence of wear in the production surfaces of good antifrictional properties on cast iron has to a large extent been fully dealt with. The influence of the general micro-structural arrangement on one or two points is of importance. Photomicrographs obtained from polished and etched specimens of two samples of cast iron showed in one case a beautiful network arrangement of the phosphide eutectic and cementite, and in the other a blotched appearance, which, in this case, consisted of large ferrite areas, around which the hard constituent was indiscriminately distributed. A microstructure of fairly large grain size is typical of a comparatively fast wearing liner, although at the same time possessing good antifrictional properties.

It must not be assumed that the presence of the hard constituent, structurally free, however, is absolutely

* Foster, Manchester Association of Engineers, Jan., 1904.

indispensable for the production of a good wearing and running liner, and, in fact, cast irons of very low phosphorous content and containing practically no structurally free hard constituent, give excellent results in this respect. The study of the influence of pearlite in this respect is still under investigation in greater detail, and undoubtedly its influence is very important. Qualitatively, it may be explained in part somewhat on the following lines. Pearlite consists of numerous very fine lamellæ of the two micro-constituents ferrite and cementite, which in individual properties represents the two extremes. The result of the polishing action on such a structure is the production of a surface containing very fine microscopic channels. Such channels behave in exactly a similar manner as fine capillary threads, distributing the lubricant undoubtedly by means of surface tension.

### Hardness and Wear.

The lack of any means whereby the wearing properties of any material can be tested and readily adjudged is sorely felt by both engineers and metallurgists alike. It is customary to use the harness number, which is, as a general rule, obtained by the Brinell method, as a means of indicating the wearing properties of metals. As applied to cast iron for the purposes of engine cylinders, this method is far from satisfactory. Cast irons giving the same hardness numeral often wear at widely different rates, and, furthermore, the influence of the presence of such elements as manganese and chromium due to their liability to produce under the influence of stresses during working overstrained superficial layers. The investigation of the yield point in this connection will doubtless throw much more light on this hitherto somewhat neglected subject.

To return to cast iron. It is extremely probable that wear due to surface disintegration is not exactly wea in the above sense, but is really a function of th brittleness of cast iron. The abrasion or relief polishing previously outlined is the true wear, in that it depends upon the resistance to deformation of the individual component grains. The whole subject, particularly in reference to the material cast iron, it will be plainly eivdent, is extremely complex and involved, and an enormous amount of work still remains to be done.

The Brinell hardness test, as applied to cast iron, is most unsatisfactory, and it is practically impossible to correlate the figures obtained in this test with the chemical constitution of the cast iron. Broadly speaking, the hardness numeral varies with the combined carbon content. The presence of such hard constituents as phosphide eutectic increase the numeral. This can only be truly said of cast irons obtained under exactly identical conditions. In such a complex alloy as cast iron this is not at all surprising, and is in all probability to be explained by the numerous subsidiary influences, chiefly the casting temperature, and the rate of cooling, which largely affect the structural arrangement and distribution and the grain size.

The impossibility of correlating the hardness numeral with other mechanical tests or the chemical constitution is doubtless largely due to the permanent bodily slip of the crystals under compression, owing to the presence of the free carbon constituent, and as a result it can only be considered that Brinell figures on cast iron are at all comparative when the conditions under which the specimens are obtained are strictly identical.

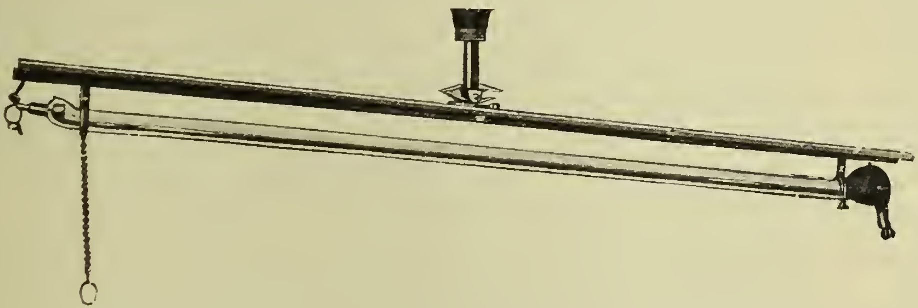


Fig. 1.—1,000 c.p. Non-Automatic Lamp, Type K, for Direct Current.

which, in normal percentages, are not detected by the hardness numeral is most important.

The unsatisfactory nature of the Brinell hardness numeral in this capacity is undoubtedly due to a multiplicity of causes. In the first place, an enormous amount of uncertainty surrounds the definition of hardness, and it is very doubtful whether the methods of determining hardness actually do determine this property in its entirety. The hardness of a body, as defined by the nomenclature committee appointed by the Iron and Steel Institute, is "the resistance offered by a body to the 'mechanical' separation of its particles." It would appear from this definition that hardness and wear are very intimately associated. Indeed, it is the author's opinion that in a homogeneous material the true hardness property is its resistance to wear. From this, therefore, the resistance to wear is a function of the cohesion of the particles, or rather, in the light of more recent knowledge concerning the architecture of crytalline bodies, is the resistance to deformation, and it is therefore tentatively suggested that the yield point gives the more correct indication of the true hardness. The high resistance to wear of some of the non-ferrous alloys, *e.g.*, antifriction alloys, is in all probability

*(To be continued.)*

## MILL LIGHTING BY COOPER HEWITT LAMPS.

[Messrs. The Westinghouse Cooper Hewitt Co. Ltd., 80, York Road, King's Cross, London, N.]

It is conceded on all hands that mill lighting by electricity is at once the safest, best, and most useful of all the forms of artificial illuminants which the owner of a mill or workshop has to choose from, and, indeed, is the only form in certain mills now permissible. To some extent there is, on the other hand, doubt as to the particular type of lamp to be adopted, each having virtues claimed not to be possessed

by the others or the same virtues in a lessened degree. Fortunately for the mill owner, there are a few good types of lamp, in the choice of which he could not go wrong.

The Cooper Hewitt lamp is in a class substantially its own. It is a mercury vapour lamp, the principle of its action being the incandescence of mercury vapour in a hermetically-sealed glass tube, distinct types of lamps having been developed for direct and alternating-current circuits. In all industries where it is necessary under certain circumstances to carry on work after dark, a soft, well-diffused illumination, similar to daylight, is a distinct advantage. In many instances Cooper Hewitt illumination has been shown to be better than daylight. These lamps have been adopted and their application absolutely approved in steel works, foundries, machine shops, garages, chemical works, textile mills, paper mills, drawing offices, composing and printing rooms. The provision of adequate illumination has been found not only to improve the quality of the work but to actually increase the quantity. Under Cooper Hewitt light there need be no falling off in quantity or quality of work after dark.

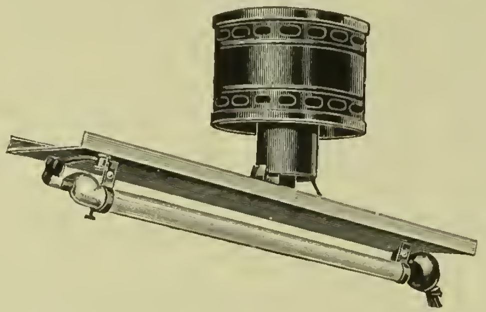


Fig. 2.—500 c.p. Automatic Lamp, Type AH for Direct Current, Type EH for Alternating Current.

Fig. 1 is a view of a 1,000-c.p. non-automatic lamp for direct current. This is the simplest of all patterns made. Lighting up is effected by tilting the mercury tube, by means of the finger chain shown, about its suspension point.

Fig. 2 shows a similar-powered automatic lamp for direct current, though this type is also made for alternating current. In this type of lamp each circuit consists of eight lamps in series and is provided with a small mercury vapour converter. Each lamp is fitted with an automatic cut-out, so that it is independent of any other. The converter is included in the price of the lamp.

Fig. 3 shows a 1,250 c.p. automatic lamp for alternating current for direct connection to the alternating-current circuit; this lamp represents the adaptation of the principle of the mercury-vapour converter and that of the well-known direct-current lamp. These lamps are for indoor installation in premises where the temperature does not fall below 50 deg. Fah.

Another well-known type is a 1,000 c.p. automatic lamp for direct current. In both these lamps the tilting of the mercury tube to effect lighting up is done automatically on the circuit switch being closed.

The advantages claimed for these lamps are: The tubes have extremely long life, during which only occasional cleaning is required; the source of light is not in contact with outside air; breakage of the tube destroys the electrical circuit; the lamp operates without mechanical regulation; in automatic tilting lamps the tilting solenoid is only in circuit momentarily on the switch being closed; absolutely steady illumination is obtained; penetration of the light into fine mechanism or interior of a machine; operation and life of lamps unaffected by vibration; prominent with which faults in weaving, defects in castings, or machinery or imperfections of polished surfaces are shown up; the Cooper Hewitt lamp is a bar—not a point—of light; the best light for the eyes owing to the entire absence of the irritant red ray.

Having given the leading features and advantages of the Cooper Hewitt lamps, we give in Fig. 4 a view of a room in a silk mill showing the character of the effect produced under this system of lighting. The succeeding views, Figs. 5 and 6, illustrate the effects in two other rooms of an American silk mill, some details about which will doubtless be interesting to other textile manufacturers, and we believe will also be suggestive of the means of obtaining an adequate artificial illumination with little or no increase of power consumption over the present supply. The original illumination of this mill consisted of about 2,200 16 candle-

Fig. 4.—General View of the Skein Winding Department. Illumination by Cooper Hewitt Lamps. Photograph taken at night.

power incandescent lamps, of which a few have been retained in small store rooms, offices, and corners needing but little light.

The main factory power station machine shop and cleaning departments located in the power station offset are equipped with a total of 337 Cooper Hewitt lamps of the following types:—

18—350 c.p. type H automatic lamps.

4—350 c.p. type H non-automatic lamps.

315—800 c.p. type K non-automatic lamps.

The illumination, as expressed in terms of nominal candle-power per square foot, can readily be used for the purpose of comparison, though they are not as accurate as if taken from illuminometer readings.

In the weaving department the illumination is 2·33 nominal candle-power per square foot, and the lighting power consumption is 1·28 watts per square foot.

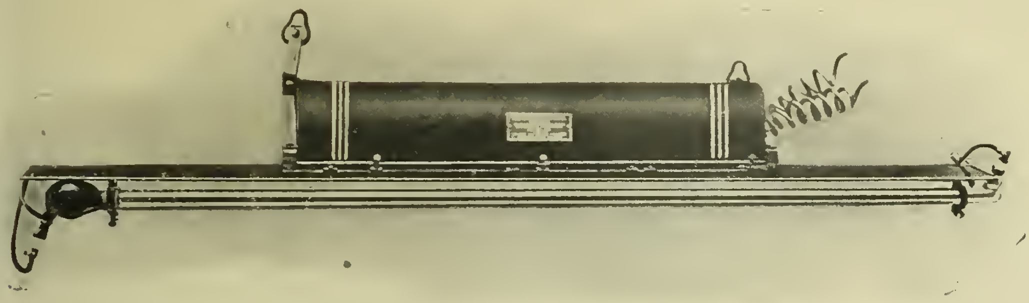


Fig. 3.—1,250 c.p. Automatic Lamp, Type F, for Alternating Current.

In the warping department the illumination is 1·62 nominal candle-power per square foot, and the lighting power consumption is ·89 watts per square foot.

In the winding department the illumination is 3·14 nominal candle-power per square foot, and the lighting power consumption is 1·72 watts per square foot.

Quilling, beaming, entering and warp-end twisting machines are all located in the rooms of the larger departments, and receive about the same amount of light.

The total illuminated area is 97,099 square feet, the total illumination, including Cooper Hewitt and supplemental incandescent lamps, is approximately 238,908 c.p., averaging 2·4 nominal candle-power per square foot. The total lighting power consumption is 137 lamps, 1,245 amperes at 110 volts, averaging 1·42 watts per square foot. As already stated, the original illuminating system consisted of about 2,200 16-c.p. incandescent lamps, giving a total illumination of 35,200 c.p., and illuminating power consumption of 132 k.w.; or an illumination of ·37 c.p. per square foot, and an illuminating power consumption of 1·35 watts per square foot.

Fig. 5.—Section of Quill Winding Department. Illumination by Cooper Hewitt Lamps. Photograph taken at night.

The Cooper Hewitt lamps are provided with white enamelled reflectors, carefully designed to give the best possible downward distribution of light, thus permitting only a small amount of light absorption by ceilings and walls.

It is the usual practice of mill men to locate incandescent lamps near the work, and, incidentally, near the eye level, giving rise to a considerable amount of eye strain.

The location of the Cooper Hewitt lamps near the ceiling, being high candle-power units, probably is one

reason for a decrease of eye trouble, but the chief gain to the operatives in comfort is probably due to the low intrinsic brilliancy of the Cooper Hewitt light, and a peculiar quality of the light due to the absence of red rays.

Since the adoption of Cooper Hewitt lamps there has been a considerable removal of glasses used to relieve eye strain among the employees. The opinion is also expressed by some of the more intelligent operatives of the mill that it is much easier to work under the Cooper Hewitt light than by daylight. This is, perhaps, the most remarkable result of the peculiar quality already mentioned.

The natural illumination of the main mill is especially good, located as it is in the open fields and provided with a large number of windows. The building is long and narrow, making the daylight distribution very good.

That the belief of the employees that the Cooper Hewitt light is very easy to work under is not an exceptional experience, but due to some quality of the light, is shown by the action of a leading plush manufacturing firm, who have adopted it for use in their cloth examining room for the first inspection in place of daylight, with the result that the rate of inspection has been very greatly increased over the daylight rate.

The difficulty most often met with when presenting the claims of the Cooper Hewitt lamp is a dislike to the light because of the absence of the red rays. A most satisfactory fact is that the apparent weak point in this most efficient form of illumination is, after all, one of its chief claims upon the attention of the average manufacturer.

Fig. 6.—General View of Loom Room. Illumination by Cooper Hewitt Lamps. Photograph taken at night.

The successful application of these lamps to ribbon looms, where a variety of colours are being handled, or to the quill-winding department and looms of the broad silk mill, is, perhaps, as interesting a fact as its introduction into the cloth-examining room and throwing department.

# THE MANUFACTURE OF GAUGES AT THE L.C.C. PADDINGTON TECHNICAL INSTITUTE.

(*Continued from page 174.*)

Two methods of correction for progressive error were considered:—

(*a*) By accelerating the motion of the top slide of the compound rest by means of a weighted lever attached to the screw. The screw of the slide was turned at a uniform rate as the saddle traversed along the bed of the lathe, by making the end of the lever move down an inclined plane, the slope of which could be readily determined from the known pitch error.

(*b*) By selecting a new train of wheels, a process demanding some considerable calculation by trial and error for different pitches, but which has proved quite possible in all cases. For example, the train of wheels, drivers 38 and 20, followers 91 and 50, gives a pitch of 24 to the inch correct to less than 0·000007.

The periodic errors corresponding to the revolution of the leading screw may be due to:—

(1) Reproduction of an error in the leading screw.

(2) An axial movement of the leading screw with each rotation, owing to both the thrust collar and bearing being out of truth.

(3) Lack of straightness or stiffness in the leading screw, causing oscillations at the point of contact of the nut.

To correct (2) the collar bearing on the leading screw was dispensed with, and the thrust was carried by a single ball bearing applied to an enlarged centre on the leading screw. The collar was turned off and the screw made to run free in its bearing. A ½ in. ball was used, and the thrust taken by a bolt screwed through a bracket and locked in position, the end of the bolt being made intensely hard.

After testing and correcting the change-wheels for eccentricity, it became evident that a more accurate and rigid leading screw was necessary. A new leading screw was cut on the milling machine on a sleeve of 2 in. diameter and 8 in. in length, with a pitch intended to be 12 threads to the inch. A split nut, 2¼ in. in length, was clamped by a weighted lever. Mounted on the original leading screw as shaft a progressive error of 0·0008 was found, with a periodic error amplitude nearly 0·0003. On substituting a short stiff shaft the latter was reduced to an amount not exceeding 0·0002, which may be considered satisfactory. The progressive error was approximately corrected by the following gear wheels:—

For 24 threads to the inch $\dfrac{45 \times 30 \text{ drivers.}}{38 \times 71 \text{ followers.}}$

For 14 threads to the inch $\dfrac{36 \times 67 \text{ drivers.}}{74 \times 38 \text{ followers.}}$

The final test, showing a satisfactory range for a length of 1¼ in., is shown in Fig. 3. This length, carefully marked, was sufficient for the gauges required.

The apparatus for effective diameter measurement is shown in Fig. 4. The micrometer carriage, mounted on balls, is constrained to move in a plane at right angles to the axis of the screw to be tested. This apparatus may also be used for measuring core diameter, by using triangular prisms in place of the small cylinders.

## Optical Projection.

Enlargement by optical projection was first resorted to for adjustment of the shape of tools for screw cutting, and verification of the shape of thread. Finding the possibilities for accuracy of measurement were greater than was thought possible, and well within the tolerance allowed, the use was extended to a large variety of gauges, particularly to plate gauges of shape, slots and holes, curvature and cone angles, etc.

The key to the method is to secure, as nearly as possible, a truly parallel beam of intense light, freed from heat rays by passage through a saturated solution of alum. An optical bench of great rigidity, and sensitive and universal adjustments, carries the gauge or tool and projecting lenses. The screen is at a distance of about 16 feet.

The necessity of a parallel beam (except for tool edges) should be obvious in dealing with gauging surfaces such as plates and screw-threads, and adjustment for tangential or grazing incidence must be as fine as possible. This limits the field for simultaneous survey to that of the area of the projecting lens. A combination of three optical elements was designed to give variable magnification up to 400. About 180 is, however, ample, and visible in undarkened room. Where it was desired, as in a few cases, to cover a larger gauge length than about ½ in., a triple achromatic lens of 2 in. diameter and 6 in. focus was combined with an astigmatic

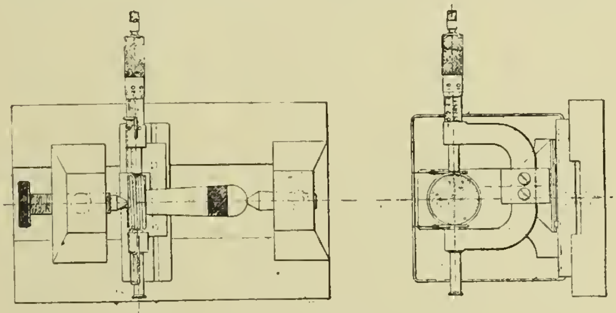


Fig. 4.—Manufacture of Gauges.

lens. The area surveyed on this extended up to over 1½ in., with 50 magnifications on a 6 ft. screen. Quick interchange of gauges and tools from optical bench to vice or lapping motor with the minimum of readjustment is essential.

## Shaping of Screw-Threads.

With a magnification of 166 a clear definition of the working edge of the single-pointed tool for screw cutting is possible to much less than a ten thousandth, this being represented by one-sixtieth on the screen. The angle and rounding off of the nose for the required pitch are adjusted with a fine oilstone to this degree of accuracy, after hardening without tempering, and quickly readjusted after wear. The same tool is used to cut the groove in a capping tool for the crests. It is then possible to ensure correct shape, provided that the relation of core to effective diameter is checked by measurement.

In the final projection of the screw-thread in silhouette a careful examination for symmetry is advisable, checking the setting of the tool. A small margin in all dimensions is left for lapping, which removes some residual errors, the margin being increased if a hardened gauge is required. For rapid lapping the screw gauge is held in a self-centring chuck on the shaft of a 1 H.P. electric motor. This is automatically controlled by a reversing switch, so that it rotates with precision, uniform torque, and any desired speed, two revolutions forward and backward,

The laps are made of cast iron, cut with a tap, or on lathe, split, and adjustable for wear.. Frequent re-tapping retains the shape. For the core a lap is prepared with a slightly thin thread, and for effective diameter a full thread with crest removed.

# BELT AND ROPE DRIVING.

By Lewis Shore.

There are various kinds of belts in use to-day for the transmission of power in conjunction with pulleys or drums. The amount of waste which is continually taking place through inattention or neglect, due in many cases to want of technical knowledge on the part of those who have them to deal with, is far greater than is generally known. If employers in many cases would give this subject the attention it deserves they would soon find they were amply repaid for the trouble in increased output of work.

## Flexibility and Tensile Strength.

Belts made from leather, camel-hair, cotton, rubber with insertions of canvas, and cotton ropes are all more or less in general use. Flexibility and tensile strength are the chief properties which make all of them valuable instruments for the transmission of power. The moment they begin to lose flexibility, their power to do work deteriorates, and their tensile strength begins to diminish also.

## Leather Belts.

Leather is a fibrous substance, and the fibres must inevitably be subjected to a great amount of friction against each other in the case of belts running over pulleys, and unless this internal friction is to some extent overcome the belt will sooner or later get into that condition we call dry and stiff, like the unoiled joints in a machine. The continued use of a belt in this state will be followed by its slipping on the pulleys, due to diminished flexibility. The loss of speed due to this cause and the loss of output of work is far more serious than is generally recognised.

## Creep in Driving Belts.

There is a certain amount of slip which takes place in all forms of belt drives, which is called "creep." This cannot be avoided, but as it is a fairly stable quantity, due largely to thickness of belt, it can be allowed for in making calculations for speeds, and does not need to be taken into consideration afterwards. The slip I am dealing with here is that which arises through the bad condition of the belt itself, which gives rise to what we might for convenience call "abnormal slip." The remedies for this, as practised by different persons, are various in character. In the absence of a correct knowledge of what causes the belt to slip, it is a common practice with many to so tighten the belt that it either won't or cannot slip, and in this way much unnecessary strain is put on the shafts and bearings, which entails loss of power in driving, a rupturing of the internal fibres of the belt, which reduces its tensile strength, and in this way shortens its life.

## Belt Compositions.

Others allow their belts to run without attention until they are as hard and dry as a board, and then resort to one or other of the many belt compositions on the market to prevent slipping. These belt compositions, in many cases, contain something which gives the belt a very sticky surface, and a very powerful grip on the pulleys, and for the time being the trouble is at an end, and this kind of nostrum is looked upon by many as their best friend, and is recommended to others as a panacea for all the ills a belt is liable to in this respect. But what about the life of the belt which has its internal fibres ruptured in this way by compositions that yield little or nothing to relieve the internal friction of the fibres, which is the actual cause of the slipping? The use of resin is another makeshift. This kind of treatment of belts can only result in loss of power, ruin of belts, and loss in output through more breakages than would otherwise be the case. I might say here that belts treated with sticky substances are more dangerous to handle on running shafts on account of their greater tendency to lap.

## Getting the Best out of Belts.

The question before us now is this: How can we get the best out of belts at the minimum of cost? For an answer to this question we cannot do better than consult the belt maker in the first instance, as he is the man above all others who knows best when leather is in right condition for the purpose it is made for. When the currier selects a number of tanned hides from which he intends to make belts he first soaks them thoroughly in water to make them soft and pliable to work, and in this state he scours and frees them from all matter of an objectionable character. Having done this, and before they are dry, he stuffs that portion of the hide he wants for belting, on each side, with a thick coating of clean dubbing, made from tallow and cod oil. In this state they are hung up in airy rooms to dry, and this usually takes two or three weeks. Now, what actually takes place in the process of drying is this, as the water evaporates from the leather its place in the fibres is taken up with grease, in such quantity that no further additions are required in the finished belt at his hands. It will be quite evident now that new belts have quite sufficient lubricant in them to last for some time after they are first put into use, and all they require is perhaps tightening once or twice to get rid of the stretching which usually takes place at the beginning. In course of time they will begin to loose flexibility through using up the original internal lubricant, and this should be supplemented from time to time as the condition of the belt suggests. Anyone who has charge of belts can, by a little observation, detect at once when a belt is in need of attention. Pulley faces which may often be seen burnished like silver is a sure sign that all is not well. It is impracticable to use dubbing in the same way as curriers use it, but we can give the belts a dressing of cod oil, which meets all the requirements of a slipping belt in an effective and economic way. I have used this oil with the most satisfactory results for the last 38 years, costing in normal times less than 4d. per pound, as against 1s. to 2s. per pound for belt compositions. A belt that has run too long without attention will absorb cod oil almost as quickly as a lump of sugar will absorb water, and is ready for use in a few minutes time. I prefer giving belts a dressing of this oil at the week-end, on the working side of single belts, and on both sides of double belts, on account of the cement in the middle, which hinders the oil in passing from one side to the other. No oil should be put on the working side of belts when they are running with weight on, otherwise they are liable to slip off the pulleys before the belt has had time to absorb it.

Camel-hair and cotton belts contain substances which the makers purposely put into them to give coherence to pulleys when in use, and oil alone is not suitable for treating these with when slipping takes place. The makers usually supply remedies for these kinds of belts, and it is best to be guided by them in case of trouble.

Cotton driving-ropes are not given to slipping like belts, on account of the shape of the grooves in which they run, they grip firmer the more weight is put on them. They need attention for internal friction the same as belts. Castor oil and blacklead mixed is good for this purpose, and I believe the makers supply a mixture of blacklead and tallow to be used occasionally.

## ECONOMY OF COAL IN POWER PRODUCTION.*

By C. E. Stromeyer, M.Inst.C.E.

The present war, with its accompanying high prices and the possibility of a trade war after the conclusion of peace, has naturally directed attention to many economic questions, including boilers, and though, in last year's memorandum I made a few remarks about their economic working, the present occasion seems an opportune one for re-examining this question from a national point of view.

Discussions about the difference between English and German economic systems of working factories have revealed that abroad a much greater harmony existed between the State and manufacturers than here, and, as a consequence, German works have adopted systems which commended themselves because of their leading to national economy, whereas here both our laws and our customs seem to force individual works to think more of themselves than of the country's welfare. Here we need only concern ourselves with the fuel question, which is briefly as follows: Our manufacturers have been spoilt by the ease with which they could obtain the very best coal in the world. When new labour-saving appliances were invented which, while increasing the output, also increased the power required to drive them, the manufacturers filled their works with them and overworked their boilers, and as this could only be done with the best of coal, slack was for long periods a drug in the market, and at one time sold for 5s. or 6s. a ton at the pit's mouth; for at that time none of our works could burn it economically.

Constant improvements in mechanical stokers have effected a change, but no overworked boiler can burn dirty coal, no matter whether it be fed by hand or by mechanical means, and slowly but surely colliery owners found that it did not pay to bring inferior qualities of coal to the surface. As most coal seams consist of several layers, of which some are rich and others poor, the poorer layers of worked seams are often left underground and buried for ever, because to mix them with the richer ones would disproportionately lower their value.

According to recent statements by coal experts this wasted coal amounts to 25 per cent of our output. This national waste is due largely to our almost universal practice of overworking boilers. Bunker coal for steamers must, of course, be as free as possible from mineral matter, and export coal has also to be reasonably pure, but there is no reason, except want of boiler power in our factories, why inferior coal should not be burnt wherever it can be got. It is done on the Continent, because first-class coal cannot be obtained, but there the works provide themselves with ample boiler power, and on the whole they obtain a higher efficiency than we can hope for with our superior coal but hard-worked boilers.

Somewhat similar remarks might be made about the burning of coke. It is a by-product of the gas works of towns, and might with gas be a valuable by-product of works which would make it their business to produce sulphate of ammonia and the volatile oils of distillation. Coke ought, therefore, to be a cheap fuel. At present, however, its production is limited, and those consumers who are compelled to use it as a fuel can be made to pay so heavy a price for it that the profits can be used for relieving the rates. Steam users naturally do not like coke, partly on account of its relatively high price and partly because it would require larger boilers than the present ones in which to burn it with as good effect as the best coal. Thus, here again, our habit of getting the highest possible duty out of our boilers may be looked upon as being one of the causes, though perhaps only a secondary one, which hamper our coal-tar industry.

Our present practice may possibly be more profitable to the individual factories and collieries than to those of the Continent, though this is a moot point, but there can be no doubt that this practice is very wasteful of our national coal resources, and it is to be hoped that after the war encouragement will be held out to those who, without loss to themselves, will assist at national economy.

Take the simple case of a shipowner who has to decide for what speed a ship, which he contemplates ordering, should be designed. He knows that with a low speed his ship cannot command paying freights, and, going to the other extreme, he also knows that if he fills his ship with engines and boilers, there will be no room for cargo, and his coal bill will be far in excess of his earnings. He will, therefore, have to decide on a medium speed, which here may be assumed to be 10 or 11 knots. With the faster ship he will be able to make 10 per cent more voyages than with a slower one, but his annual coal bill will be increased 20 per cent and his carrying capacity slightly decreased, on account of the extra 20 per cent of engine, boiler, and bunker capacity. Leaning on past experiences, he may be able to say to himself that his prospective earnings would be about the same, no matter whether he were to decide on the 10 or the 11-knot boat. At this point national economic considerations ought to influence him, and he ought to say to himself: The 11-knot boat will carry 10 per cent more cargo than the 10-knot boat, but it will burn 20 per cent more coal. My profit will be the same with either speed; therefore, in order to assist my country in saving coal, I will decide to have the slower boat.

The factory owner is faced with other, but similar, problems, and will find that he too can make selections amongst a number of alternatives of which he should choose the one which, while it does not affect his profits, will be of economic advantage to the nation. It will be my endeavour to review these several alternatives.

The cost of fuel depends, of course, on the cost of labour, and that depends on the average cost of living. This will necessarily be increased after the war on account of the heavy taxation to which we as a nation will be subjected; but it is impossible to make even the vaguest guess as to the extent to which future prices of fuel will be affected by the increased cost of living. For convenience of illustrating the subject a pre-war price of 12s. 6d. per ton will therefore be used as a basis of the present calculation. We may assume that the coal consumption for a first class modern steam engine can be reduced nearly down to 1 lb. of coal per indicated horse power, or nearly four tons per year continuous working. In most factories only about one-third of the full time is worked, whereas the interest on capital is a continuous charge, and the total cost, including wear and

* From the memorandum by the Chief Engineer of the Manchester Steam Users' Association for the year 1915.

tear, was in one modern factory found to be £12 per indicated horse power per annum, at a time when the cost of fuel was 12s. 6d. per ton. Had the factory been working night and day the cost would have been £6 per indicated horse power per annum.

This compares very unfavourably with 35s. to 50s. per electric horse power, which is approximately the cost of continuous-power production in some parts of Sweden, Norway, and on the slopes of the Alps. These districts are rapidly realising that they can control enormous powers, and when these have been harnessed they are sure to attract to themselves many of our industries. After the war wages in this country are likely to rise, and the disproportion is likely to be increased.

Then also, as America is not going to burden herself with additional taxes, the cost of living will not be increased in that country. But the most threatening possibility is that Prussia, true to her national traditions, not to be saddled with a national debt (her present one of 600 millions being merely an industrial one created when the State acquired all the railways), may repudiate all her internal war loans, and after a few years of severe personal hardships, the taxation in Prussia, and consequently the average cost of living and with it the price of labour and of coal, will be as low as before the war.

We may therefore expect that some time after the war our cost of creating power for industrial purposes will be greater than in other countries, so that even without considering the question of economising our national coal resources it will be necessary for individual works to practise extreme economy as regards coal consumption.

In order to be able to reach a reliable starting point as to possible fuel economies, a table of engine performances is given in the memorandum which is not here reproduced. The deductions which can be drawn from that part of the table dealing with cotton spinning mills are, roughly speaking, that compound engines using steam of 100 lbs. pressure consume about 3·0 lbs. of coal per indicated horse power. For high-pressure compound engines, the net consumption is about 2·15 lbs. of coal per indicated horse power, and for triple-expansion high-pressure engines it is about 1·65 lbs. of coal per indicated horse power. These results are neither as good as the results promised by engine builders nor as those attained during trials. This is but natural and should not be allowed to influence intending purchasers, for it must be remembered that a factory engine stands idle for two-thirds of its time, and that the raising of steam and the banking up of fires costs much fuel, say 0·3 lb. per indicated horse power. If we make this further deduction we arrive at the following average net consumptions per indicated horse powers under ordinary working conditions, which are, of course, never as favourable as trial conditions, at which the makers attend and try to minimise all losses.

Old compound engines working with about 100 lbs. pressure consume about 2·70 lbs.

High-pressure compound engines consume about 1·85 lbs.

High-pressure compound engines with superheated steam consume about 1·45 lbs.

Triple-expansion engines consume about 1·33 lbs.

The figures given in the table show that as a rule only about 1 lb. or 2 lbs. of coal per indicated horse power, or, say £1 to £3 per annum, is likely to be saved by modernising an old power plant. If, in addition, arrangements were to be made, by providing ample boiler power, for burning cheaper quality of coal, a very great monetary saving might be effected, but unless collieries will provide inferior fuel to individual works, this desirable policy can only be carried out by large combinations of power producers.

The Newcastle Electric Supply Company has in a way shown what can be done in this direction, and their work has also revealed the difficulties which would have to be overcome in other districts than their own before success can be obtained. Their leading idea seems to have been to provide trunk wires which would do for power what railways do for goods. They provide collieries and ironworks with outlets for any power which may be produced from their waste coal and from the waste heat of their furnaces, and they thus provide the means for the sale of this power, which would otherwise be wasted. This company has in some respects been favoured by local conditions, but it had also to contend with serious difficulties which are even more serious in other districts. It had the advantage of promises from all the large works on the Tyne to buy power from them, and its first power stations could therefore be designed to work with large units and with a minimum of cost. Subsequently the North-Eastern Railway Company agreed to purchase all its power for local traffic. On the other hand, the Board of Trade limit on the voltage in the trunk wires made these connecting links very expensive, and as nearly every old power station had its own voltage and its own frequency of phase, practically every amalgamation necessitated the erection of entirely new installations. An initial difficulty, which has, however, been nearly overcome, was that the numerous Corporations had the right to exclude outsiders from supplying their little districts with power. But they have seen the advantage of adapting their voltages and frequencies of phase to those of the company, and now they buy their electric power from it for the purpose of distributing it amongst their customers.

As far as can be ascertained, the charge per unit of electricity, if used all the year round without a break, has been reduced to about £4 10s. per electric horse power. For 8-hourly supply the charge would, of course, be much heavier, possibly as heavy as the cost of individual power production by a modern steam engine. One reason why power can be produced thus cheaply, is that the company with its network of transmitting wires can deal with collieries on the following lines: Each colliery can bring or brings to bank some very dirty coal or shale, which is absolutely unsaleable. Of this fuel about 25 per cent can be burnt in the colliery boilers, but the remainder is thrown on waste heaps and is occasionally burnt there. Now the company, by installing a power station with ample boiler power close to the collieries, could consume all this apparently valueless fuel and produce four times as much power as was needed by the colliery. The collierly buys its quarter share, and the rest is carried away in the trunk wires. Ironworks are utilised in the same way. The heat wasted by the gases which escape from blast and other furnaces is far in excess of the power requirements and was largely wasted, because without a trunk system to carry away the surplus power it could not be used. Now all this waste power is bought at a cheap rate and distributed.

In other industrial districts the conditions for conveying and selling power are rather unfavourable. The numerous Corporations still exclude outside producers from within their boundaries, nor will they buy from outsiders, and they have not the necessary powers for building power stations outside their own districts and thus utilising the waste fuel of collieries. To produce cheap power from fuel which has

had to be carted to their own works is out of the question. They also have not the necessary powers for supplying outsiders, and are therefore in the most unfavourable position for acting as power brokers or intermediary for the buying and selling of power. What makes matters worse is that nearly every Corporation has its own particular voltage and phase, so that it could not, even if it would, buy and sell power from and to others. The Board of Trade may justly be blamed for this unsatisfactory condition of things, for instead of fixing on comparatively low limits for voltages in trunk lines and encouraging a multiplicity of systems, they might easily have encouraged uniform systems and step by step they could have learned to tolerate higher and higher voltages.

This condition of things is not likely to change until factory owners learn that, with a proper system, they could easily be supplied with power at a cheaper rate than that at which they can produce it. They will then insist on being supplied at as low a rate as is to be found in other districts, and Corporations and other power producers will then be forced to standardise their systems and connect up trunk lines for the conveyance of power.

Another means of distributing power and economising our coal resources is to convert coal into gas, distribute it in pipes, and sell the by-products, thus encouraging agriculture and the coal-tar industry. In a certain sense our Corporations work on these lines, and even produce a third by-product—coke. The production and sale of coke might be encouraged more than it is, because it is a smokeless fuel, but here again we find the same conflicts as in the electrical field: Corporation gas is too costly for cheap heating and power production, and producers of power gas are practically prohibited from introducing their pipes into towns.

It might be possible to combine the gas and electricity systems, then gas and its by-products could be produced from waste coal, and this gas could be used in internal-combustion engines, to produce electricity. Unfortunately, however, the gas engine is not as reliable as might be wished, and it is also disliked because of the irregularities of its revolutions, which cause flickering of lights and troubles in spinning mills. We have therefore to wait, but possibly not for long, for the perfection of the internal-combustion turbine.

At present the steam turbine seems to combine the greatest number of advantages; not only is its running very steady, but the new designs are reported to be very economical. The most interesting novelty is probably the Lundholm turbine, which consists of two discs and blades revolving in opposite directions. As there is no difference of expansion of the two discs, there is every prospect that the clearances of the blades can now be reduced to a minimum, and that this very serious source of loss will be materially reduced.

The fuel economy question may therefore be briefly summarised by saying that hardly any improvement is likely to be effected in the economic working of boilers for, as is well known, there is only a margin of about 20 per cent to 25 per cent to play with. Considerable pecuniary saving might often be effected by increasing the number of boilers, so as to be able to burn a poor and relatively cheap fuel if this can be got. For instance, if, when best coal costs 20s., dirty coal of, say, 75 per cent heating value were obtainable for, say, 6s. per ton, the coal bill would be reduced to one-half, but only if the local colliery can bring this dirty coal to bank, and if the boilers are large enough to burn it.

Our chief hopes will therefore have to be centred on engine improvements, for here large savings might be possible, because at present about eight units are thrown away for every one doing useful work. Improvements have been and still are being effected by inventors, and research workers have little scope for their activity. Research workers have already indicated very clearly that the internal-combustion engine can attain a much higher efficiency than the steam engine, but the high cost of the fuel, either oil or gas, nearly balances this advantage, and constant engine troubles and repairs are both annoying and costly. Research workers have also shown that the turbine should be much more efficient than the reciprocating engine, but it is only comparatively recently that the efficiency of the steam turbine has equalled and slightly surpassed that of its older rival, and we look to inventors, rather than researchers, to reduce the remaining losses to a minimum, for the most convenient form of extracting power from coal is still the old method of burning it under a boiler. Central power stations are not limited in their choice to the steam engine for power production, and in view of the very high theoretical efficiency of internal-combustion engines, they very likely hope to see the internal-combustion turbine brought to perfection.

From a national economic point of view the combination of the internal-combustion engine with electric distribution of power would seem an ideal one. Our collieries would then be encouraged to mine even our dirtiest coal. This coal would produce by-products for farmers and for the coal-tar industries and supply the engines with suitable gas, and our factories would receive their power at a lower cost than they could produce it.

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

## ENGINE FOUNDATIONS.

*To the Editor of "The Industrial Engineer."*

Sir,—With reference to the interesting article appearing in your journal on "Engine Foundations," Vol. v., No. 127, on January 22nd, 1917, I should be obliged for a little of your space for comment.

In dealing with the cores usually left in the concrete bed to receive the foundation bolts, Mr. A. V. Cl… tapered holes with the greatest width at the bo… wooden cases. His object in having as the re… shaped filling of concrete after grouting u… that the pull on the foundation bolts tends t… material . . . more tightly to the fou…

Such a tendency is, under ordinary circ… as, if the concrete bed surrounding the c… grouting material should form a perfectly… the bed, which is in most cases still … three weeks' setting. Since this parti… shaped core is therefore unnecessary, I w… which has been used in bridge work, and… wooden cases, placing their wide end at t…

This saves the method of withdrawal… of the sides," as the narrow end of … paratively easy to withdraw whole, … impossible with the larger end at the bott…

This creates a saving in timber and in… the cases again, which in such an instan… of machinery in a power house is con… faithfully,

Prestwich, February 15th, 1917.

# Patent Applications.

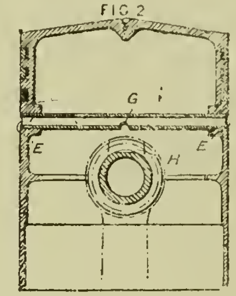
*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### PISTONS.

102,228.—ALBION MOTOR CAR CO. and T. B. MURRAY, South Street, Scotstoun, Renfrewshire.—June 30th, 1916. No. 9,201.—Lubricating oil passes from the exterior of a piston by means of a groove and communicating passages to the gudgeon bearing. In

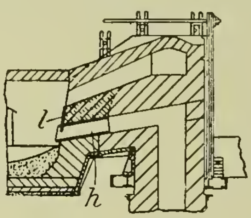
FIG 2




the construction shown, the groove communicates by a tube E and an aperture G therein with an aperture H in the end of the connecting-rod. In a modification the groove communicates with a slot in the gudgeon by passages in the bosses carrying the gudgeon.

### GASEOUS-FUEL FURNACES.

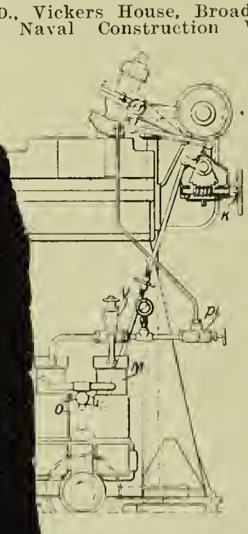
102,234.—CLYDE FURNACE CO., 116, Hope Street, and W. DIXON, 38, Bath Street, both in Glasgow.—July 22nd, 1916. No. 10,341.—In repairing the port blocks of open-hearth furnaces by the method described in Specification 10,853/13, means such as a plate *l*, is




provided for supporting the repairing material at the front end of the block while in a plastic condition. The plate may be held in a slot cut in the tube *h* around which the port block is formed, and may have a hole for convenience in manipulation.

### INTERNAL-COMBUSTION ENGINES.

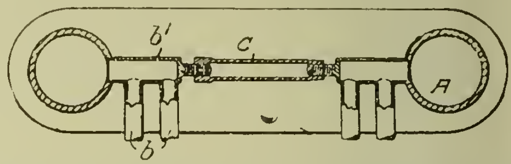
102,281.—VICKERS LTD., Vickers House, Broadway, Westminster, and J. McKECHNIE, Naval Construction Works, Barrow-in-




uary 20th, 1916. No. 960.—The liquid ump which delivers it at a uniform into the cylinder is controlled by the ked by a cam through an adjustable lever by which the time the injection begins and its duration can be adjusted. The mechanism employed is preferably that described in Specification 18095, 1915. The pumps M deliver fuel in excess, the surplus escaping through a relief valve N which is loaded to the injection pressure. The supply to each cylinder is controlled by a stop cock p1. A throttle valve O in the suction pipe of the pump or the suction valves are controlled by the hand wheel K by which the injection valve mechanism is adjusted. Specifications 24127, 1912, and 24153, 1912, also are referred to.

### STEAM SUPERHEATERS.

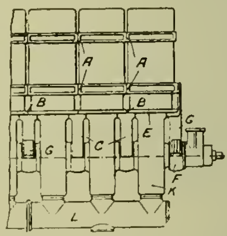
102,282.—V. SMITH, 53, Bath Road, Wolverhampton, Staffordshire. —January 25th, 1916. No. 1,170.—A group of two or more U-shaped steam-superheating tubes *b* is connected to its headers A by means of tube branches *b*1 connecting the corresponding ends




of the U tubes and adapted to be forced into the inlet and outlet openings in the headers by a screw device between the tube branches. The screw device may consist of a nut C engaging with oppositely threaded screwed studs on the tube branches.

### INTERNAL-COMBUSTION ENGINES.

102,286.—A. CRAIG, Earlsdon House, Earlsdon, Coventry.—February 1st, 1916. No. 1,515.—In multi-cylinder engines in which the cylinders form a rigid block, the crankshaft bearings are carried by hangers C which are bolted to the flanges E of the cylinders. The lower half of each bearing is carried by a loose cap F, and each hanger, or each alternate one, is provided with




a bracket G for supporting the engine. A crank casing K, preferably of the construction described in Specification 101,997, is placed between each adjacent pair of hangers, and makes an oil-tight joint at the top with the cylinder and at the sides with the hangers. The oil from the casings drains into a tank L. The cylinders are provided with flat faces A, B and are bolted together. The cam shaft also may be carried by the hangers C.

### CLEANING BOILER TUBES.

102,287.—REITER and GRUENWALD, 1, Galleria Mazzini, Genoa, Italy.—February 5th, 1916. No. 1,757. Addition to 332, 1915.—To enable the fire-tube cleaning apparatus described in the parent specification to be used for cleaning water-tube boilers, a tubular

FIG 2

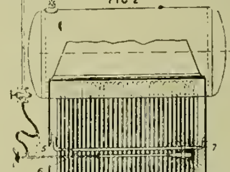
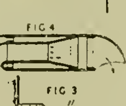



FIG 4

FIG 3

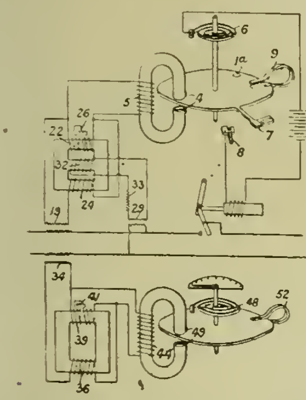



support 6 is fitted in the boiler, and the cleaner 5 is suspended from it by hooks 7, Fig. 2; or the cleaner may be supported on a flanged sleeve 11, Fig. 3, inserted into an orifice in the wall. The preferred form of suction nozzle is shown in Fig. 4.

### ELECTRIC METERS OR RELAYS.

102,335.—BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING Co., 2, Norfolk Street, Strand, Westminster.—June 12th, 1916. No. 8,310.—An electric meter or relay of the induction type is connected with a transformer such that the induced pressure bears a decreasing ratio to the current in the main circuit, and so

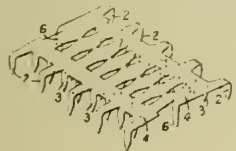
compensates for the increasing torque of the instrument. The effect in the case of a meter is to give a more even scale, and in the case of a relay to preserve the time-lag under heavy overload, and so enable a series of relays to operate selectively. As shown, the winding 44 of the driving-magnet of the meter is connected in shunt with one coil 39 and in series with an opposing coil 36 on the transformer, the core of which becomes magnetically



saturated at a low current-value. An adjustable resistance 41 is inserted between sections of the coil 39, and the current may be supplied from an ordinary transformer 34. The winding 5 of the relay magnet is similarly connected to coils 22, 24 on a highly-magnetised core, and to an ordinary current transformer 19. An additional winding 32 on a third limb of the core may be connected through a resistance 33 to a pressure transformer 29 to cause the relay to operate with a lower current in one direction than in the reverse direction. The driving-magnets are fitted with shading-rings 4, 49, and the disc armatures are controlled by springs 6, 48 and damping-magnets 9, 52. A piece of soft iron 1*a* on the relay disc is attracted by the magnet 9 as the contact-arm 7 approaches the contact-piece 8.

## BELT GEARING.

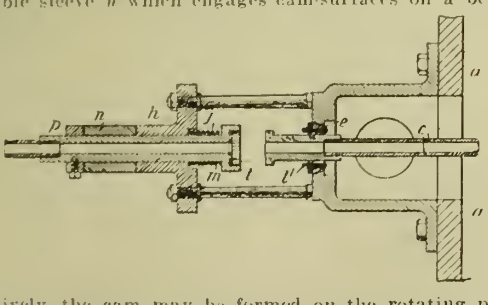
102,295.—E. G. RITCHIE, 170, Lochee Road, Dundee. February 29th, 1916. Nos. 3,020 and 11,791.—A fatening for driving belts comprises a metal strip having on each side spikes 2, 3 turned down in two rows, and a third row of spikes 4 bent down from slots



in the plate. Central tongues 6 are bent down into the gap between the belt ends to position the fastening. The spikes are staggered as shown and may be corrugated vertically, the concave surfaces facing outwards. The plate may be in two parts hinged together by a pin or link.

## BURNERS.

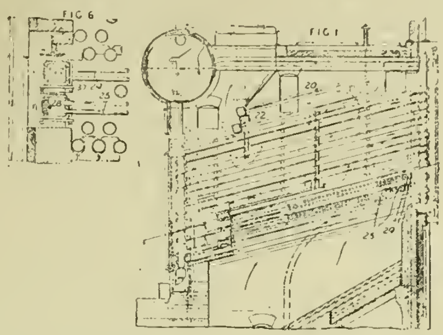
102,346.—C. RICHARDS and A. RICHARDS, Imperial Works, Darlaston. July 7th, 1916. No. 9,574.—An easily removable liquid-fuel burner *c* is provided with a device *e* for positioning it in a furnace *a* and a sliding cam-operated connecting-sleeve *j* through which fuel is supplied. In one form, the sleeve *j* is withdrawn into the position shown, against the action of a spring *m*, by a rotatable sleeve *n* which engages cam-surfaces on a bearing *h*.



Alternatively, the cam may be formed on the rotating part and act against projections on the thrust-collar *p*; or a spiral slot or groove in the part *n* may engage a pin on the sleeve *j*. Holes provided in the device *e* for cleaning and observation purposes may be closed by rotating a similarly perforated disc *t* provided with actuating and retaining studs *t*1.

## STEAM GENERATORS AND SUPERHEATERS.

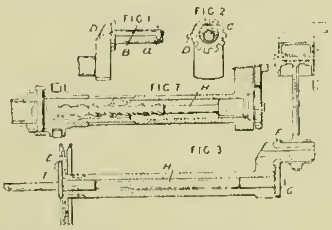
102,352. BABCOCK AND WILCOX, 30, Farringdon Street, London. July 13th, 1916. No. 9,867.—The tubes of a superheater fitted in a water-tube boiler having longitudinal tubes are curved and arranged transversely between the water-tubes. The superheater may be connected to a U-tube superheater placed above the water-tubes. The curved superheating-tubes 24, 25 open into headers 27, 28 supported by girders in the boiler walls. Steam may flow through groups of tubes in series; or groups of tubes may be separately connected to the outlet header 22 of the super-



heater 20 placed above the water-tubes. The tube-plates of the superheater header may be stepped. Removable panels 37 are provided in the boiler walls to afford access to hand-holes in the headers.

## FLUID-PRESSURE ENGINES.

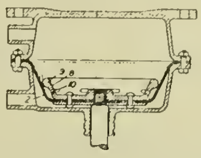
102,353.—H. O. WILKINSON, Petteridge, near Matfield, Kent.—July 13th, 1916. No. 9,878.—The stroke of an engine is varied by adjusting an eccentric B on the crank-pin *a* with which it normally operates as one. In the construction shown in Figs. 1 and 2, a toothed wheel is arranged on the eccentric and engages a stop D carried by the crank-web. In the construction shown in Fig. 3, the eccentric is adjusted by toothed gearing F, G actuated



by a central shaft H carrying an arm I, which may be adjusted relatively to, and secured to, a disc E on the shaft. In the construction shown in Fig. 7, the shaft H is actuated by screw-and-nut gearing. The nut is actuated by a grooved sleeve controlled by a forked lever. The application of the invention to a built-up four-throw crank-shaft is described.

## PISTONS.

102,368.—J. C. STACK, 167, Emmett Road, Inchicore, Dublin.—Oct. 14th, 1916. No. 14,624.—A diaphragm packing for a vacuum brake comprises a pan cup, or cone-shaped plate 8 having a perforated rim with a flat portion 10 and outer portion 9 of flat, curved,



rounded, or bulbous formation to allow the diaphragm 2 to assume a close fit around the outer part when under atmospheric pressure.

## INTERNAL-COMBUSTION ENGINES.

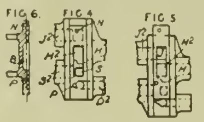
102,388.—W. A. HALL, 7, Gracechurch Street, London.—Jan. 6th, 1916. No. 231.—To enable paraffin and the like to be used in spray carburettors, it is heated to a uniform temperature before spraying. For this purpose, the fuel-pipe B receives heat from the exhaust pipe A by being coiled around it, and both pipes are

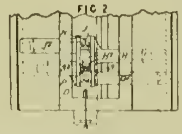
enclosed in a casing E containing a solid, either a salt or an alloy, having a fusion-point at about the temperature to be maintained, so that the latent heat may, on occasion, be transferred to the fuel. The casing has a non-conducting coating. At starting, some of the fuel is heated electrically at F.

## STEAM ENGINES.

102,355.—H. DAVIES, Park Lane, P. F. MASON, 26, Elworth Street, both in Sandbach, and A. WOOD, 19, The Avenue, Elworth, near Sandbach.—July 18th, 1916. No. 10,064.—[illegible]haped intercepting slide valve, applied to a compound en[illegible]wn in the closed position in Fig. 2, as arranged for si[illegible]ng in Fig. 4, and

as arranged for compound working in Fig. 5. The valve, Fig. 6, has a central cavity B and two apertures N, P. In the position shown in Fig. 4, steam passes to the high-pressure cylinder through the port P and passage D2, and exhausts therefrom through ports and passages J1, H2, B, S, S2 to the low-pressure

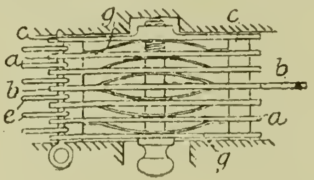




exhaust outlet; and steam passes to the low-pressure cylinder through ports N, J and passage J2. In the position shown in Fig. 5, the high-pressure exhaust passes through ports and passages H, H2, J, J2 to the low-pressure cylinder.

### STAPLING.

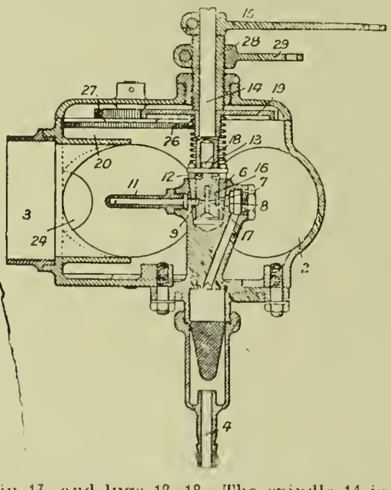
102,360.—W. W. HARTLEY, 116, Junction Street, Newton Heath, Manchester, C. H SHERWOOD, Hampton House, Hampton Road, South Shore, Blackpool, and H. K. MACKAY, 106, Burton Road, West Didsbury, Manchester.—Aug. 27th, 1915. No. 12,005/16. A



device for spacing belt-fasteners prior to their insertion by a machine such as that described in Specification 12,338/15, consists of a number of plates $a$ spaced by springs $g$ on either side of a central fixed plate $b$ and separating the fasteners $e$. The plates slide towards or away from one another on rods $c$ passing through holes in the plates, extensions on the end bow springs pressing one rod $c$ against the fasteners. To permit of this, the plate holes for this rod are elongated. In a modification, the plates are spaced by an arrangement of helical springs and stepped washers actuated simultaneously by a lever co-operating with a notched quadrant.

### INTERNAL-COMBUSTION ENGINES.

102,455.—C. H. ADAMS, Fairmead Woodside Road, Woodford, Essex, and A. J. RATH, of E.N.V. Motor Co., Hythe Road, Willesden, Middlesex.—June 30th, 1916. No. 9,245.—A circular variable passage around the nozzle 11 is formed by two semi-circular grooves of varying width formed in a pair of rollers 20, geared together and to the fuel control means. The fuel supply to the nozzle is controlled by a rotary conical plug 6 having a number of small passages 7, and an axially adjustable plug 16 fitted therein. Both plugs are rotated by a handle 15 through a



spindle 14, pin 13, and lugs 12, 18. The spindle 14 is geared to the rollers through wheels 19, 27, and the rollers are geared through teeth 26 on their peripheries. Independent adjustment of the fuel supply, particularly desirable on aeronautical engines, is effected by rotating a screwed sleeve 28 by a handle 29, which causes the inner plug 16 to move axially and, by its circumferential groove 17, t[illegible] the fuel passages 8, 9 in the conical plug 6. Fuel ent[illegible]d air through two inlets 2, and mixture leaves at 3.

## INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

VOL. V.] MARCH 8TH, 1917. [No. 130.

## The Industrial Engineer.

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# EDITORIAL.

## COUNT ZEPPELIN.

As we go to press with this issue we learn of the death of Count Zeppelin, the famous inventor of the airships which bear his name. The announcement of this fact may be regarded by some sections of the British public with a sense of relief, and, indeed, by others with a sense of satisfaction, particularly by those who have suffered from the machinations due to the unwarranted employment of those engines of destruction over unfortified places in this country. Generally, however, the Great British public, in spite of the dreadful character of the War, which was started by the Germans themselves, will not, we are sure, descend to the vulgar abuse which has been characteristic of some German journals and speakers when referring to the deaths of some of our own eminent men who were engaged in carrying on the War on our behalf. Least of all will engineers do this, for they have been trained and have a natural aptitude for giving credit to the mechanical achievements of those of other nationalities, whether acting as enemies or in alliance with ourselves. They will be no less generous in their recognition in Count Zeppelin's case. His has undoubtedly been a remarkable personality, a patient and persevering pioneer in a realm of engineering which has attained its highest efficiency in the present War. Count Zeppelin's share in aircraft success is on a par with that of the American Wright Brothers in the lighter and swifter types of machine, and is far and away above all others in dirigible airship construction. Many attempts at other construction of dirigible airships had been made in different parts of the world prior to the advent of Count Zeppelin in the same field, one of such attempts being by Schwartz, another German inventor, who made many persevering attempts to construct an airship with a rigid envelope of aluminium. This was in the early 'nineties. Count Zeppelin followed somewhat in the footsteps of Schwartz, whilst endeavouring to avoid as he went along the mistakes of the latter. Zeppelin's first airship was launched on July 2nd, 1900, and was 416 ft. in length by 38 ft. in diameter, with two little engines of 16 H.P. each. It had 17 gas compartments, and was, so far as general design is concerned, very similar to the most modern Zeppelins. This ship was purely experimental, and after six months of work the Count's funds gave out and experiments were suspended. His second machine followed in 1906, and was wrecked within three months of its construction. Success, however, came in 1907 with machine No. 3, which flew for 2½ hours and reached a height of 2,500 ft. No. 4 followed shortly afterwards, and astonished the world by making two great voyages. On July 4th, 1908, she covered 235 miles in a cruise of 12 hours' duration, and on August 4th she started a voyage during which she covered 378 miles and spent 20 hours 45 minutes in the air. After being away from home for just over 31 hours, and while anchored to the ground at Stuttgart, she broke away from her moorings, rose in the air, caught fire, and burst. This tragedy resulted in public subscriptions being raised to help the Count, some £250,000 being collected in this way. Thus enabled to pursue his experiments, Z 5 came out in 1909, and made a 700-mile trip. In 1909 Z 6 appeared, and in it the Count pilgrimaged to Berlin, and was received by the Kaiser. Z 7 was a nine-days' wonder, and was wrecked with many journalists aboard. Z 8 was wrecked and Z 10 was burnt. Z 11, Z 13, and Z 17 were taken over by the German navy before the war. Between June, 1910, and November, 1913, 23,271 civilian people were carried in Zeppelins without the loss of a single life.

# THE INTERNAL-COMBUSTION ENGINE.

By Dugald Clerk, D.Sc., F.R.S., M.Inst.C.E.

*(Continued from page 184.)*

So far I have discussed only the development during the modern period, that is, since 1876, but an earlier examination shows that, as usual, English inventors were very much alive to the necessity of improving the means of obtaining motive power. England and France in the early stage were at work long before Germany. This even the German text books acknowledge. In an important German work, written by a well-known German engineer, Herr Hugo Güldner, and published in 1903, I find the list of early inventors as follows:—

1791. John Barber, English Patent No. 1833.
1794. Robert Street, English Patent No. 1983.
1801. Lebon, French Patent No. 1799.
1823. Samuel Brown, English Patent No. 4874.
1833. Wellmann Wright, English Patent No. 6525.
1838. William Barnett, English Patent No. 7615.
1841 James Johnston, English Patent No. 8841.
1842. Drake, English Patent No. 562.
1852. Christian Reithmann, experimental four-stroke engine built in Munich.
1854. Barsanti and Matteucci, English Patent No. 1655.
1858. Degrand, French Patent No. 21301.

It will be observed that German industry appears under the name of Christian Reithmann for the first time in 1852. There are other early inventors who do not appear in the patent lists. Professor Farish, Professor of Physics in Cambridge University, described an engine of the Lenoir type and showed a model working upon his lecture table as early as 1817. The Rev. W. Cecil, of Cambridge, produced an interesting atmospheric gas engine in 1820, and read a paper fully describing it before the Cambridge Philosophical Society in that year.

From this examination it will be seen that the internal-combustion engine, like all great inventions, is the result of a long-continued struggle, and much thought and ingenuity, the outcome of the work of men of many nations. It is indeed rare to find an invention which can be considered as entirely novel. A search through the records of the past invariably shows tentative efforts to produce a given result. The early efforts always failed, partly from want of fundamental knowledge—in the case of the gas engine, ignorance of the properties of gaseous explosions—and partly from the lack of engineering means of carrying inventions into practicable effect. It is one thing to conceive an idea and quite another matter to carry it into effect in actual operative iron and steel. In the early days of engines constructive appliances were exceedingly imperfect; and, accordingly, we find James Watt rejoicing when he gets a cylinder bored sufficiently true to prevent the passage of a coin between the cylinder and the piston at any point of the stroke. Great work had to be done, and progress in machine tools made before it was possible to bore cylinders with the accuracy required in modern gas and oil engines. Progress is now more rapid on the constructive side, because machine tools are capable of an accuracy measured in thousandths of an inch, and also because of advancing knowledge of the nature of the working fluid, flame, which acts in the interior of those cylinders. The advance, too, of thermodynamics and the better understanding of limits of efficiency prevent inventors from following false paths. Accordingly, we may expect further rapid advance in these motors during the next decade.

In this great subject, as in others, we have a right to be encouraged by the story of past effort and the realisation of the present, to look forward to a future in which Britain will perform her full share in the work of development and production. Broadly, development has been great and general, and the field of the reciprocating steam engine has been effectively invaded for both stationary and locomotive purposes on land and water. The steam engine, in its various forms, however, still supplies much the largest proportion of motive power. The United Kingdom had stationary engines for manufactures and agriculture in 1907 of about 10·8 million horse power; the nited States had in 1909 about 23¼ million horse power, similarly mostly steam engines. Of this, in Britain, internal-combustion engines gave about 6·4 per cent. and America about 4·2 per cent. The engines on the ships of the world have a power of about 24 million horse power, a very small proportion internal combustion. The younger engineer of to-day has a huge field of effort open to him, and he will need all the scientific and practical knowledge available to fit him for his task. His position is enviable compared to that of the pioneers, and his progress should be rapid and great. The older combustion engineers have justified their faith and earned an honourable position among the workers of the world.

The fate of the British Empire in the future depends upon the scientific engineer; our present existence as a free nation depends upon our sailors and soldiers; but the more distant future is subject more to the efforts of engineers than to the labours of war or politics.

## Discussion.

The Chairman (the Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S.), in announcing that the discussion was open, said the paper was a thoroughly sound one on a very difficult subject. It was very comforting to hear Dr. Clerk say that Britain had been in the forefront of gas-engine developments, and that there was a larger proportion of gas engines in England and America than in Germany. The question of the large cylinder versus the small cylinder was a subject of very great discussion in this country about two years before the war. The Germans believed that the large cylinder engine was the best type, and some said that we were very much behindhand, and that British engineers and British workmen were incapable of making a successful large gas engine. But the experiments of scientists like Clerk, Hopkinson, and Dalby showed that in the large cylinder the heat transmitted to the walls was very much more intense than in the small cylinder. In fact, other things being equal, the heat varied roughly as the square root of the dimensions of the cylinder. Therefore, in a certain size of cylinder, say 200 H.P. or 300 H.P., the heat became so intense that no metal would stand it. The surface of the metal was heated to such an extent that it was compressed beyond its elastic limit, and on cooling it was submitted to a tension beyond its elastic limit, so that hair cracks made their appearance all over the surface, and eventually the crack went right through and the cylinder burst. Steel was worse than cast-iron in this respect. Thus the Germans were wrong as regards the large cylinder, and the English, who were conservative, took the right course, and did not go in to any extent for large cylinders. Further, our experiments showed that the weight per horse-power increases very rapidly as the

cylinder increases beyond a certain small size, so that the only way to get a very light engine of large power was to have a great number of small cylinders—in other words, a multi-cylinder engine—and collect the power either by gearing or any other means on the shaft to be driven. That had not been carried out to any extent in ships, and in this direction, undoubtedly, there was a field open to the engineers.

Professor E. G. Coker, speaking with reference to the Gaseous Explosions Committee of the British Association, said Dr. Clerk had mentioned that the Committee had been working for nine years, but he did not say—he could not very well have done so—that all through those nine or ten years it was he who had been the inspiring influence. Dr. Clerk had gathered together a number of people interested in the gas engine, both engineers and chemists, and kept them all very busy for a good many years working on different problems, the nature of which he had indicated, until the outbreak of the war, when the Committee was not able to continue the activities it was then engaged upon. All the members of the Committee, however, hoped that after the war the Committee would carry on its work as before. There was one point concerning which Dr. Clerk would do the audience a favour if he would say something upon it, and that was what had happened in regard to the gas turbine since, he believed it was, the Leicester meeting of the British Association. At that particular time they had been promised a paper by a German engineer on the 1,000 H.P. gas turbine, which was going to be a great revolution on anything that had been done before. They had been promised some very high efficiencies; but the paper did not arrive, and he did not remember hearing anything about it since. He believed some experiments had been made later, and would be glad to hear what progress had been made since that time.

Mr. A. Evans, referring to the Hornsby or Stuart Akroyd engine, reminded the author that in describing this he said that the oil was injected into the combustion chamber while the air was being drawn into the main cylinder. He was under the impression that, although that was the practice in the ordinary Hornsby engine, at the beginning of the Stuart Akroyd invention the oil was injected into the cylinder at the moment of highest compression. In other words, Stuart Akroyd had anticipated what was now known on the market as the semi-Diesel engine. Another point was whether Dr. Clerk had not made a mistake when, in speaking of the Daimler engine, he said that the governor worked on the exhaust valve and kept the valve open when it wanted to cut the engine out again and otherwise let it function in the usual way. He was under the impression that that valve was kept closed.

Mr. W. L. Oakden asked which internal-combustion engine had attained the highest efficiency, and how that efficiency compared with the best efficiency of any other kind of engine.

Dr. Dugald Clerk said he had had much pleasure in working with Professor Coker and the other members of the British Association Committee. They had been able to carry out many experiments, and were proud to find they had discovered many things which the Germans had failed to do. With regard to the gas turbine, Professor Coker was referring to the Holzworth turbine. At the Dundee meeting of the British Association he had been asked to give a short note to the Engineering Section on the gas turbine. In connection with that he asked Herr Holzworth, who said he was coming to the meeting, to give some of the results obtained with his 1,000 H.P. gas turbine. He also asked him if he would answer a few questions which he sent him, concerning efficiency, total power, etc. Just before the meeting he got a wire which gave a much lower efficiency and much lower power than had ever been given before in the published information on the subject, and it was quite evident that in 1912 the experiments were a failure. He had heard since that greater success had been obtained, but on the cycle they were operating with in 1912 they could not possibly equal the efficiency of the steam turbine. People seemed under some misapprehension on the matter of the gas turbine. It was not the faintest use designing such a machine unless some of the advantages of the internal-combustion engine were obtained. The great advantage of the internal-combustion engine was that a higher thermal efficiency could be got than by any thermodynamic method yet discovered. The steam turbine had made marvellous progress, but efficiencies were not high efficiencies from the thermal point of view; they did not equal those of the internal-combustion engine. If a combustion turbine were made giving an efficiency something like that of the steam turbine, it was no use attempting to put it on the market, because the steam turbine had practical advantages. For instance, the temperature conditions were very much easier, whereas the temperature conditions of the gas turbine were very onerous. So far as he knew, the gas turbine had not yet succeeded, although it might do so in the future. As to the method of injection in the Hornsby oil engine, he was called in to test the Stuart Akroyd engine at a very early stage, and that was an engine in which the oil was injected during the suction stroke, and compression took place and the ignition occurred exactly as he had described it. There had been attempts to work the other way, but, so far as practical matters were concerned, they were a failure. There was a good deal of misapprehension about this question of the injection of fuel into air, and a great many people claimed the origin of the Diesel engine. As a matter of fact, there were many specifications describing the exact operations of what Mr. Stuart Akroyd called the injection of fuel into the air. One was a Liverpool inventor who was some years before Stuart Akroyd, and long before Diesel. There was nothing new in it, and there were many patents in which the compression was accomplished with air only, and the heat of the walls of the cylinder was sufficient to cause ignition. Where they all failed, and indeed where Diesel himself at first failed, was in realising the necessity of producing intensely as fine spray, the fuel required. Dr. Diesel had told him that his first experiments were a complete failure because he had not a fine spray. He worked his engine, and could not get a single ignition, until one day he got a terrible explosion and blew the top off his cylinder, and was very much encouraged. That led him to study some of the earlier work, and he discovered that the fine spray was the main point. In none of the engines before Diesel had that been appreciated. As far as he knew, the first engine to work with flame injection was his own in 1887; but even then the economy was not equal to the ordinary explosion, but the Diesel idea was to get compressed air hot enough to ignite the finely-sprayed fuel. Diesel certainly succeeded in using a heavier fuel than could be used in other types. The suggestion with regard to the valve of the Daimler engine was correct. The valve was kept closed. As to the efficiency of internal-combustion engines, there was nothing to choose between the Diesel and the ordinary explosion engine in the matter of brake thermal efficiency. If indicated thermal efficiency was disregarded, it would be found that brake thermal efficiencies of the order of 30 or 31 per cent were obtained, but the indicated efficiency was increased because the compression

of the air for the spray producer was never taken in, and Dr. Diesel himself at the Institution of Mechanical Engineers admitted that the German method of calculation was wrong and gave too high an efficiency. With the Diesel engine the brake efficiency was the true efficiency. The mechanical efficiency of the Diesel engine was generally exceedingly low, something of the order of 75 per cent against 86 per cent in an ordinary combustion engine.

A hearty vote of thanks was accorded Dr. Clerk for his paper.

*(Concluded.)*

## VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.

*(Continued from page 187.)*

### Other Forms of Gear.

It would be quite impossible, without unduly extending the length of this paper, to attempt to describe all the various forms of this sliding type of gear. M. I. Rutishauser, an eminent French engineer, divides them into no less than nine classes and 26 sub-divisions. Other variations to which passing reference may be made are:—

A construction in which there are two permanent trains between the driving shaft and the countershaft, either of which can be brought into operation. By this means two speeds can be given to the secondary shaft whereby the total number of indirect speeds obtainable is doubled.

A construction in which a plurality of secondary shafts are employed for the purpose of balancing the strains on the shafts and increasing the tooth surface without materially increasing the weight.

A construction in which the wheel on the countershaft of the permanent train between the driving shaft and the countershaft is loosely mounted on this shaft, and a clutch is provided for uncoupling it from this shaft when the driving shaft is coupled direct to the driven shaft to give the direct drive, so that during the direct drive only one of the gear-wheels on the countershaft is in motion.

A further development of the latter is a construction in which the wheel on the countershaft of the permanent train between the driving shaft and the countershaft is mounted to slide on this shaft, so that when the direct drive is in operation said wheel can be drawn out of mesh with the wheel on the driving shaft; whereby both the countershaft and all the wheels on it are quiescent on the direct drive. This would seem to be the ideal form of this type of gear, but difficulties occur in side meshing two sets of wheels at the same which this form of gear entails.

The common practice with the sliding type of gear is to mount it in an independent box, which in some cases is made as a complete unit with the engine, but which is usually arranged at a convenient distance behind the engine and is connected with the driving axle carrying the road wheels by means of a propeller-shaft. The enclosing and carrying of this shaft in a tube adapted to operate as a torque member has led some designers to make the gear-box part either of said torque tube or of the casing enclosing the rear driving axle. The objection to mounting the gear-box either on the casing of the rear driving axle or on the back end of the torque tube is that it increases the unsprung weight, but this is to some extent compensated for by the fact that the presence of a gear-box is considerably less evident to the occupants of a vehicle when it is located in this position than when it is mounted in the usual position on the frame of the chassis. This is probably due to the reduction of tremor owing to the better isolation of the gearing from the body of the vehicle. The drawback of increasing the unsprung weight is, however, considerably modified when the gear-box is carried on the forward end of the torque tube, which is a practice that has much to commend it.

When the gear-box is an independent unit, it is of importance that it should be so mounted as to prevent any binding on the shafts due to distortion of the frame of the chassis. Either a spring suspension or a three-point suspension is usually adopted to this end. A convenient three-point suspension consists in carrying the gear-box fore and aft by means of trunnion bearings arranged concentric with the driving and driven shafts, and preventing rotational movement of the box by connecting an arm, extending from the side of the box, to the frame by means of a link.

### Silence in Gear-box.

The great desideratum in a gear-box is now silence, as it was not until the internal-combustion engine had been brought to a practical state of silence that the noises arising from the gear-box were fully realised. The noises from a gear-box may be divided into two classes. First, that produced by the running of the gears under load, which is more or less constant; and secondly, that produced by the clash engagement of the wheels or clutches, which is intermittent. While the former can be materially eliminated by careful design and workmanship, the latter must depend to some extent on the human element.

Dealing first with the noise produced by the running of the gears. It may be taken for granted, so far as present knowledge goes, that spur-gearing of the sliding type cannot be made to run under load for any length of time without emitting a certain amount of noise, and that the problem of silent running depends to a very large extent on the care with which the gear is produced, and particularly so in relation to the teeth. To reduce the noise to a minimum, the following essentials must be observed: (1) the greatest care must be exercised in the production of the wheels, especially with regard to the teeth; (2) the box must have the necessary stiffness and its resonance be reduced as much as possible; (3) the shafts must be of ample diameter, be kept as short as possible, and be supported by a sufficiency of bearings so as to have a minimum of deflection; (4) the wheels must be small, in order to keep the peripheral speeds as low as possible; (5) the wheel centres must be absolutely accurate; (6) the wheels must be efficiently lubricated; (7) if ball-bearings are used, means must be provided to give some sort of a surface support in addition to the line contact of the balls in order to damp off the vibrations set up in the gear; and (8) single or double helical wheels must be used where possible.

As a certain amount of noise is inseparable from two spur-wheels running together under a load, however well and accurately they may be made, another form of drive must be employed if a really silent gear-box is required. The London General Omnibus Company arrived at this conclusion by force of circumstances, as they could not reduce the noise in their omnibus chassis sufficiently to get it passed by Scotland Yard until they substituted a chain drive for the spur-wheel drive in their gear-boxes, and all of us are probably aware from actual experience how silent-running these omnibuses are on all speeds.

### Chain Drive.

Chain-drive gear-boxes were used as far back as 1901 by Brooke, of Lowestoft, but these boxes were not particularly quiet, as chains of the roller type were used, whereas the silence of the modern chain-drive gear-box is due to the use of chains of the "inverted tooth" type. In the gear-box used on the London General Omnibus Company's "B" type of chassis, an improved chain of the "inverted tooth" type, manufactured by the Coventry Chain Co. Ltd., and known as the "Coventry Noiseless Chain," is employed, in which, for a given pitch, a rivet of larger diameter can be used, which not only increases the breaking load but also increases the wearing area of the rivet, the result being that a chain of but two-thirds the width of the standard pattern can be employed to transmit the same load. This firm has devoted considerable time and attention to the perfection of the chain-drive gear-box, and the problem they had to face was the finding of suitable wheels to run at a common centre distance to produce the desired speed ratios. That they have successfully tackled the problem is instanced by the large number of different designs of these gear-boxes that they have produced to meet the various demands of the automobile trade. One of these boxes is shown in Fig. 9.

In four-speed gear-boxes the additional speed is sometimes produced by an additional chain and pair of sprocket wheels, and sometimes by means of an additional spur-wheel on the countershaft with which the spur-wheel on the driven shaft employed for the reverse engages through an intermediate pinion.

In addition to the advantage of noiselessness, chain-drive gear-boxes have many other advantages, amongst which may be cited: (1) flexibility of drive, which also operates as a safety valve and limits the destruction which a careless driver may cause by careless driving; (2) the obtaining of the speeds and the reverse with a minimum number of wheels; and (3) the ease with which chains can be replaced as compared with the replacement of a gear-wheel.

The noise produced by the clash engagement of the gears arises chiefly from the difficulty of getting the teeth of the wheels into engagement, and this seems to depend essentially on the pitch of the teeth, on the peripheral speed of the wheels, on the shape of the engaging edges of the teeth, on the speed at which the wheels can be brought into engagement, and on the force resisting the inter-engagement of the teeth. The accepted practice is to use wheels of small diameter so as to keep the peripheral speed as low as possible, to keep the pitch of the teeth relatively small, and to round off the engaging edges or sides of the teeth. Although it is the common practice to round off the edges or engaging sides of the teeth, a much easier and quieter engagement results if the edges or engaging sides of the teeth instead of being rounded are chamfered or bevelled off, as this not only allows the teeth to become meshed to a greater depth before the drive comes on them, but also lessens the force resisting the complete meshing of the teeth, whereby the continued end-on movement necessary to bring the wheels completely into mesh is facilitated. This does not decrease the surface contact of the teeth subject to wear if the edges or engaging sides are chamfered or bevelled off on one side of the teeth only.

### Changing of Gear.

Various devices have been introduced in the transmission gear between the clutch and the driving axle carrying the road wheels for the purpose of facilitating the changing of the gear, the most successful being a spring drive arranged between the clutch and the gear-box, and a secondary clutch arranged either in front of the gear-box to couple and uncouple the element of the main clutch carried by or coupled to the driving shaft of the gear-box, or at the rear of the gear-box to couple and uncouple the driven shaft of the gear-box and the propeller shaft of the transmission gear, but these devices are outside the ambit of this paper.

### Automatic Gear-changing Devices.

Various systems have also been employed to make the changing of gears more or less automatic so as to eliminate the human element. All such systems embody two essential features, one a method of pre-selecting the gears and the other the method of timing their change. The automatic gear-changing devices which have attained any measure of success may be divided into three types: (1) the mechanically operated; (2) the electrically operated: and (3) the pneumatically operated. The first type may be divided into two classes: (*a*) those in which the clutch pedal releases a spring which brings the gears into mesh, this spring being compressed by hand at the time the selection of gear is made; and (*b*) those in which the clutch pedal operates the gear. In this latter arrangement no springs are employed, the mechanism simply transferring to the clutch pedal the operation which is usually performed by a hand lever.

The Linley device, described in Fig. 10, which has for some years been successfully employed on the Commer cars, is an example of the mechanical type.

In the electric system the pull on the sliding elements of the gear is effected by solenoids which are brought into and out of action by means of switches suitably located so as to be operated by the driver of the vehicle, the arrangement being such that the switches merely operate as selectors for the particular gear desired, the actual closing of the energising circuit being completed by the movement of the clutch pedal. Although this system has not been employed in any vehicles manufactured in this country, it has been successfully employed in several cars manufactured in the United States and imported into this country, of which probably the best known is the Cadillac. Electricity would seem to be better adapted for the purpose than compressed air, as a source of current is available on most modern cars, at all events of the pleasure type, whereas a compressed-air system, besides requiring an air-compression plant, involves a far more complicated construction, and unless the apparatus necessary for working this system can be made considerably more simple than that which has already been evolved, or the compressed air can be also utilised for some other useful purpose on the car, it does not appear to be a commercially practical proposition. The electric current required to operate these electric charge-gear systems is so small as to be practically negligible. In a test of one of these devices drawing its current from an 80 ampère-hour 12-volt battery, 134,000 changes of gear were made without exhausting the battery.

The absence of noise with a direct drive gear has led some designers to provide a direct drive on more than one speed. A common method of obtaining two direct drives is to employ two crown wheels—of different diameters—on the differential box and two bevel pinions on the propeller shaft, suitable clutches being provided for coupling one or other of said pinions on said shaft.

This construction gives a direct drive at two different speeds, and when used with a gear-box has the additional advantage that it doubles the number of ratios of speed available. Some makers have adopted this system to obtain a direct drive on all speeds, but it has never been a commercial success owing probably to the complication involved in providing suitable coupling devices for the driving pinions, to the fact that such a construction involves all the wheels of the gear constantly running, and to the increase of the unsprung weight on the back axle. One of the most successful of the direct-drive-on-all-speeds gear is that employed in the Sizaire-Naudin light car, Fig. 11. The Humphris gear is of a similar nature.

The number and ratios of the gears depend essentially on four factors:—the power of the motor, the size of the road wheels, the weight of the vehicle laden, and the nature of the roads the vehicle has to traverse; but even when these four factors are constant a wide diversity of opinion exists as to both the best number and the best ratios. This much, however, may be said. The present tendency is to limit the number of gears to three and to reduce the gear ratio rather than increase it, and this latter probably arises from the desire to enable vehicles to travel on the direct drive for the greatest possible percentage of the distance travelled so as to avoid gear changing as much as possible.

The speed of the vehicle in relation to the speed of the engine is governed by the reduction in the final drive at the back axle, which is usually a single one. Some makers, however, employ a double reduction at the back axle, the merit of which—when used purely as a reduction gear—appears to be the ability to keep the wheels of each pair in the gear-box giving the various speeds of a more uniform size.

Before leaving this particular type of gear, which, as before stated, easily holds the first place in automobile construction, it will be well to tabulate both its advantages and its disadvantages. Its advantages are: (1) simplicity of construction, (2) comparatively light in weight, (3) easy to understand and manipulate, and (4) ease and low cost with and at which worn parts can be renewed. Its disadvantages are: (1) abnormal wear due to the clash engagement of the teeth of the wheels, (2) liability to considerable damage by bad driving, and (3) noise. What further improvement can be made in this type of gearing seems to be "in the lap of the gods," but as far as it is possible to forecast it would seem to lie in the direction of the use of some other or new metal or alloy for the box whereby increased stiffness and decreased resonance without increasing the weight will be attained, and in the all-round use of wheels having helical teeth.

## CHAIN GEAR BOX.

This box, Fig. 9, gives three forward speeds and a reverse, the forward speeds, other than the direct drive, being produced by sprocket and chain-wheels, and the reverse by spur-wheels. On the driving shaft V is fixed a sprocket-wheel A, and on the driven shaft W are two loosely-mounted sprocket-wheels B and C. On the countershaft X are fixed three sprocket-wheels D, E, and F. On the inner end of the driving shaft, which forms the spigot for the inner end of the driven shaft, is a collar G, having internal teeth H, which forms part of a claw-clutch. Between this collar G and the sprocket-wheel B is a sliding sleeve J, which carries two rows of teeth L and M forming parts of claw-clutches. The sprocket-wheels A and D, B and E, and C and F are coupled by means of chains of the Coventry "noiseless" inverted-tooth type. By moving the sleeve J to the left, the teeth L engage the teeth H, whereby the driven shaft is coupled to the driving shaft, which gives the direct and top drive. By sliding the sleeve J to the right, the teeth M engage an internal row of teeth N carried by the sprocket-wheel B, whereby the sprocket-wheel is coupled to the driven shaft, which gives the second speed through the wheels A, D, E, and B. On the driven shaft beyond the sprocket-wheel C is a sliding sleeve O, on one end of which are teeth P and on the other end of which is a spur-wheel Q. By moving the sleeve O to the left, the teeth P engage an internal row of teeth R on

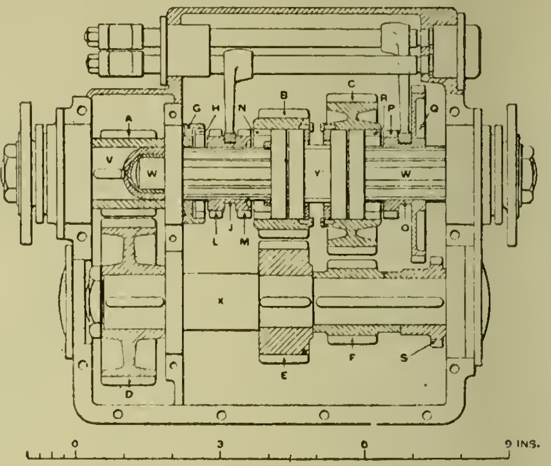


Fig. 9.—Chain Gear-Box.

the sprocket-wheel C, whereby the latter is coupled to the driven shaft, which gives the first speed through the wheels A, D, F, and C. By moving the sleeve O to the right, the spur-wheel Q is brought into mesh with a spur-pinion S on the countershaft, whereby the reverse is obtained through the wheels A, D, S, and Q. It will be seen that, as when two shafts are coupled together by chain and sprocket-wheel gearing they both rotate in the same direction, the reverse can be obtained by the use of two spur-wheels only without the use of an intermediate wheel.

## LINLEY AUTOMATIC CONTROL.

In this control, Fig. 10, a spur-pinion A is loosely mounted on the driving shaft V—which is arranged in axial alignment with the driven shaft W—and is constantly in mesh with a spur-pinion B fixed on the countershaft X. On the driven shaft are loosely mounted three spur-pinions C, D, and E, each of which is provided on one side with claw-teeth, and two of which, C and D, are respectively constantly in mesh with pinions F and G on the countershaft. Mounted on the squared end V[1] of the driving shaft V is a sliding double-claw clutch H, which, if

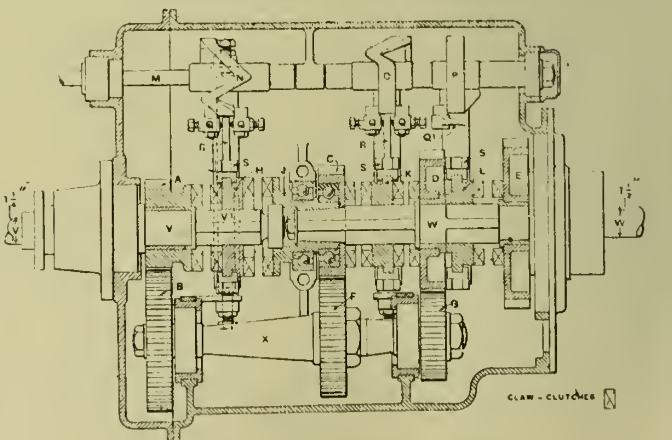


Fig. 10. Linley Automatic Control.

moved to the left, engages with teeth carried by the pinion A, thereby locking the pinion to the driving shaft; and if moved to the right engages with teeth carried by a collar J fixed on the driven shaft and forms the spigot for supporting the bearing for the inner end of the driving shaft, thereby locking the driving shaft direct to the driven shaft and producing the direct drive and top speed. On the squared parts of the driven shaft

between the wheels C and D and D and E are mounted two other sliding claw-clutches K and L, the former of which, if moved to the left, couples the pinion C to the driven shaft for producing the second speed, and if moved to the right couples the pinion D to the driven shaft for producing the first speed. The other clutch L, if moved to the right, locks the pinion E to the driven shaft for producing the reverse through an intermediate pinion—not shown—which gears with both E and G. Mounted parallel with the driving and driven shafts is a cam-shaft M, which is rotated by the operation of the change-speed lever through suitable mechanism. This shaft carries three cams, N, O, and P. With each of the cams N and O two rollers, carried by two spring-controlled levers Q, of the fly-to-centre type, engage, and with the cam P one spring-controlled lever $Q^1$ engages. The springs controlling these levers are not shown in the illustration for the sake of distinctness. Between each pair of levers Q is an arm R, forming part of the swinging fork S, by means of which each of the sliding clutches H and K is shifted, and the lever $Q^1$ is carried by a sleeve which carries the swinging fork S by which the sliding clutch L is shifted.

When the change-speed lever is in its neutral position the peripheries of the cams are all parallel so that the fly-to-centre levers are lying dormant and the clutches are all disengaged. The claws of the clutches and the parts with which they engage are undercut so that they remain in engagement even against the pressure of the spring of the fly-to-centre levers so long as a driving pressure is on them, but when this pressure is released, either by de-clutching the engine or by throttling the engine down so as to remove the driving effort temporarily, the spring operates to cause one of the clutches to become operative either alone or at the same time that the other clutch becomes inoperative.

The operation of changing speed is as follows: when the change-speed lever is brought from the neutral notch into the first-speed notch, it rotates the cam-shaft for about one-fifth of a turn. This causes the cam N to throw over one of the pair of fly-to-centre levers Q, thereby putting tension on the spring which controls these levers, with the result that the moment that the claws of the clutch H come opposite to those of the pinion A the spring acting through the arm R causes them to engage automatically, thereby locking the pinion A to the driving shaft. At the same time the movement of the second cam O has performed a corresponding operation on the pair of fly-to-centre levers Q controlling the clutch K, and the spring acting through the arm R causes this clutch to engage with the first speed pinion D, thereby locking it to the driven shaft and completing the train A, B, G, and D for producing the first speed.

When the change-speed lever is moved into the second-speed notch, which operates to rotate the cam-shaft through a further part of its revolution, no further motion is communicated to the levers O controlling the clutch H, so that the clutch remains engaged with the pinion A. The second cam O, however, operates to transfer the tension of the spring of the pair of fly-to-centre levers controlling the clutch K in the opposite direction, so that when the driving strain is released, the spring operates through the arm R to throw the clutch K out of engagement with the first-speed pinion D and into engagement with the second-speed pinion C.

On putting the change-speed lever into the third-speed notch, the cam shaft is again partially rotated, which causes the cam O to operate to put tension on the spring of the pair of fly-to-centre levers O controlling the clutch K, so that when the driving strain is released, the spring operates through the arm R to draw the clutch K out of engagement with the pinion C, and causes the cam N at the same time to operate to transfer the tension of the spring of the fly-to-centre levers Q controlling the clutch H in the opposite direction, so that, when the driving strain is released, this spring operates through the arm R to throw the clutch H out of engagement with the pinion A and into engagement with the claws of the collar J on the driven shaft, thus coupling the driving and driven shafts together and giving the third or top speed with a direct drive.

To obtain the reverse, the change-speed lever is moved into the reverse notch which causes the cam N to operate to engage the clutch H with the pinion A, and at the same time causes the cam P to operate to allow the clutch L to be pulled over—by a spring not shown in the illustration—to engage with the reverse pinion E which is driven from the pinion G on the countershaft through an intermediate pinion, which is also not shown.

It will be seen that the reason that the gear does not change immediately on pulling over the change-speed lever is that the clutches cannot disengage themselves while under load. The pulling over of the lever simply compresses a spring which cannot move the clutches owing to the pressure on their engaging claws. When this pressure is removed by de-clutching or by releasing the driving effort, the spring which has been compressed asserts itself and changes the gear. The gear changing can only be automatically effected when the engine is actually driving the car, so that if it becomes necessary to change the gear when the car is over-running the engine, it must be effected in the usual way, namely, by de-clutching before actuating the change-speed lever.

### SIZAIRE-NAUDIN GEAR.

In this gear, Fig. 11, a crown-wheel A is mounted on the differential casing U of the live back-axle Z, and on an extension V of the propeller-shaft are three spur-pinions B, C, and D, which give the three forward speeds by engagement with the crown-wheel A. The driving shaft V is mounted in bearings E carried by a frame F, which is so mounted on a longitudinally-arranged shaft located under the back end of the driving shaft—not visible in the illustration, which is a view in plan—that it is free to rock transversely and move longitudinally in relation to the crown-wheel A, for the purpose of bringing one or other of the spur-pinions B, C, and D into engagement with the wheel, the driving shaft being so connected to the propeller-shaft of the engine as to allow of the required longitudinal movement, and the usual universal

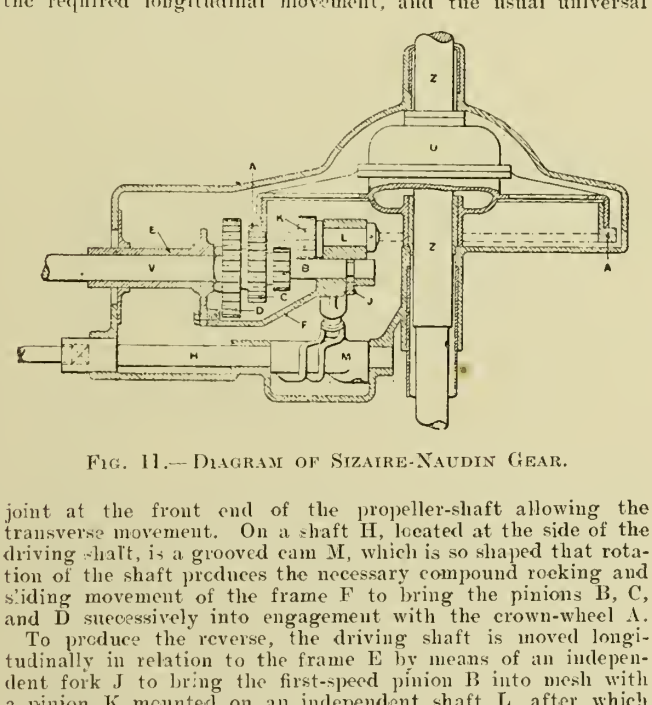



Fig. 11.—Diagram of Sizaire-Naudin Gear.

joint at the front end of the propeller-shaft allowing the transverse movement. On a shaft H, located at the side of the driving shaft, is a grooved cam M, which is so shaped that rotation of the shaft produces the necessary compound rocking and sliding movement of the frame F to bring the pinions B, C, and D successively into engagement with the crown-wheel A.

To produce the reverse, the driving shaft is moved longitudinally in relation to the frame E by means of an independent fork J to bring the first-speed pinion B into mesh with a pinion K mounted on an independent shaft L, after which the frame E is moved by the action of the shaft H and the cam M to bring the pinion K into mesh with the crown-wheel A, its intermediate position between the spur-wheel B and the crown-wheel A giving the reverse motion to the crown-wheel.

### HUMPHRIS GEAR.

A gear of a similar nature is the Humphris gear, which consists of a pinion—having hemispherical teeth—mounted on the end of the propeller-shaft, which gears with one or other of a series of countersunk holes or hemispherical recesses in the face of a disk mounted on the differential gear-box of the axle to be driven. Each of the concentric rows of holes or recesses represents a different gear ratio, the slowest speed being obtained when the pinion on the propeller-shaft is in engagement with the outer row of holes or recesses in the driving disk, and the highest gear when said pinion is in engagement with the innermost row of holes or recesses. The end of the propeller-shaft is so mounted that it can be moved transversely within certain limits, for the purpose of bringing the pinion in and out of engagement with the driving disk. To change the gear, the end of the propeller shaft is swung over to disengage the

pinion, after which the pinion is moved longitudinally on its shaft to bring it into position to engage the particular row of holes or recesses in the driving disk which will give the desired speed. The propeller shaft is then swung back to bring the pinion into engagement with the disk. It is claimed for this gear that there is no side thrust and that it has an efficiency of 85 per cent.

*(To be continued.)*

## THE CHOICE OF A POWER GENERATOR.

By F. R. Parsons.

It not infrequently happens that a comparatively small or medium-sized power user is called upon to decide (1) what is the cheapest form of power to instal for his needs; (2) which is the most economical in use; and (3) which of the two commonest forms of power, viz., steam or gas, will best fulfil his own peculiar demands. This affords a wide field for discussion, and moreover, opens up a somewhat contentious subject. However, it is not intended in this article to cover anything like the whole of the ground coming under this survey, but rather to offer a few suggestions of a practical nature on the particular points embodied therein, and also to discuss broadly some of the pros. and cons. entering into the question of power in the event of such a choice of a power medium having to be made. The writer has designedly not included the perhaps obvious alternative to either of the forms of power enumerated, that is to say, electric energy, for the very good reason that the adoption of this form of power is not so generally favoured except in cases where the power demands are more or less of an intermittent character, or the plant so segregated as to call for the adoption of separate and independent power units. What has to be said applies more to the continuous, day-in and day-out type of power plant, which possesses a more clearly defined and regular sphere of action.

### Fuel as a Factor.

In the first place, the question of fuel must be a factor determining largely the choice of any power plant. With this also, as an equally important one, must be the consideration, whether steam, in any other form than that of a power generator, will be required among the productive agents in connection with the methods and processes of the business. If the latter is an indispensable feature, then this will constitute a fairly strong argument in favour of the use of steam power. If not, then fuel alone need be the determining factor upon which will hinge the question as to whether steam or gas shall be the medium.

Nowadays the modern steam boiler for small powers is efficiently adaptable for a fairly wide variety of fuels, and reasonable economy may be assured by the use of low-grade fuels to an extent almost impossible a few years ago. This is a distinct advantage, inasmuch as a prospective user of steam power may be in a position to obtain at a relatively cheap rate perhaps an unlimited supply of some waste products from adjacent factories or mills.

### Steam for Power and other Purposes.

Then, again, when steam is required for various auxiliary purposes, apart from the creation of power, but in addition thereto, another thing to be considered is what proportion of low-pressure steam will be required for the various demands outside the generation of power. It should be taken into account that generating high-pressure steam and reducing it to low pressure for heating, or other kindred purposes is a wasteful process in fuel, and involves generally the provision and maintenance of complicated fittings to enable the reduction to be secured. In such instances it is quite possible to secure a greater economy, and more efficient conditions, by providing a separate low-pressure boiler to meet the steam demands outside those required for power purposes. In this connection it is again possible to utilise a grade of fuel, or a class of refuse which otherwise would be unfitted for high-pressure steam raising; thus enabling large quantities of low-pressure steam to be raised at a minimum of cost.

### The General Lay-out.

The internal arrangements of a factory, or a mill, or, as it is sometimes termed, the general "lay-out" of the plant, is, and always must be, a determining factor in the consideration of what form and of what type the power generator must be. It is not always that the latter scheme is but a part of a general scheme which includes the co-ordination of power generation with that of power transmission, for then the building of the structure, the lay-out of the plant, and the disposition of the various machines and equipment, together with the position of the power generator can be treated as a concrete whole, and have embodied in the scheme the very best that modernisation of methods and processes can suggest. More often than not the contrary to this exists. It is a case of supplying power, and means of transmitting this power to existing conditions—conditions which might be highly conducive to efficient and economic service, or the very reverse. A centrally-disposed power unit, dealing with the whole of the plant, might, in some instances, be the very essence of efficiency, and productive of the best and most economic results. While, on the other hand, the "lay-out" might be so oddly arranged, through force of unpreventable circumstance, as to make it a matter of great difficulty, if not of impossibility, to arrange for one central drive.

### Separate Power Units.

In the first case, the leaning towards a steam unit might have some considerable weight behind it, as it is generally conceded that a much greater economy is effected by the use of one steam unit of a given power than by this same power split up into individual and separate units. In the second place, assuming the disposition of the plant to be as described in the preceding paragraph, the securing of greater efficiency and economy might very reasonably be expected to follow the installation of separate gas-power units. True, the loss in splitting up the total power demands into units holds good in the case of a gas engine, as with steam, but not nearly to the same extent. In other words, practice has shown that a greater proportion of economy might be expected by running separate gas engines than by installing separate and individual steam units to make up the total power.

Then there might be another cogent reason why it is desirable to arrange the power supply in sectional units. It might happen that certain portions, or certain sections of the plant would require to be run at periods not coinciding with the others. One might require to be run the night through while the others are stopped. Another might require power only for a few additional hours nightly, the remainder of the sections being stopped at the usual break-off time. Or, generally, the nature of the work, or methods of production, might be such as to distinctly favour the employment of intermittent power demands. In either case it would follow that a centralised steam unit, or a number of separate and independent steam units, would be disadvantageously employed, this being due to the variable demands upon the steam boiler, consequent upon lack of continuity of favourable and economical steaming conditions.

and other losses due to long steam mains, perhaps deficient in size, inadequately protected against radiation, and imperfectly drained.

### Separate Gas-Engine Drives.

In such a case as that exemplified the prospective power user will be well advised to consider the advantages offered by a scheme embodying separate and independent gas-engine drives; for, notwithstanding what has already been said respecting loss of efficiency, such a scheme might easily prove to be the cheapest to run and maintain, and entail less labour and attendance. In this connection, however, it must be understood that in whatever manner this suggested segregation is secured it is vital to running economy and all-round efficiency to see that each unit bears its full load. There should be no need to remind engineers that a gas engine is most economical and efficient when working at from three quarters to full load; therefore, on no account should the normal transmission demands be so arranged as to be served by an engine rated at from 50 to 75 per cent in power above that actually required.

### Some Further Considerations.

Given the prospective power user to be so situated as to be quite outside the acquisition of a cheap fuel, the only source of supply available being ordinary steam coal, then he will find that a gas-power installation is going to be a neck-and-neck competitor. And if in his business he is not in need of steam for auxiliary purposes, the matter of selection becomes still further narrowed down. Arising out of this will, of course, come the need for examining the points of economy as between a gas-producer plant and an engine using town's gas. Here, again, the fuel question comes uppermost. It is generally accepted that anthracite for fuel for gas-producing purposes is, from the point of view both of efficiency and economy, the cheapest and best fuel to use. Furthermore, the use of such fuel reduces to a possible minimum the amount of labour necessary to run the plant, this being assisted by its low-ash content, ensures the highest degree of reliability, and permits the narrowest margin of occupied space. But more important, perhaps, than all is the fact that gas produced from anthracite is of a more consistent quality, is cleaner, and therefore more fitting for use in the engine cylinder.

### Relative Costs.

With this to go upon, it is now necessary, if the choice of a power plant is between a producer and town's gas, to consider the relative costs, basing our calculations on the price of good anthracite, and the price of town's gas per thousand cubic feet. It is quite possible to find, when the first calculations are made, that the saving effected by producing gas from best anthracite may vary from one-third to one-sixth the cost of town's gas. But as against this must be set the cost of producer plant, together with attendance and upkeep. Attendance may, in certain circumstances, be almost a negligible factor, since the engine attendant would scarcely notice the extra charging and cleaning duties imposed upon him. But in the event of the purifying apparatus requiring periodical attention, cleaning or refilling, as would happen if fuel of a bituminous character were used, or in the event of the fuel having to be brought some distance to the generator, or otherwise required much handling until it reaches the hopper, it must follow that labour charges under this heading may quite conceivably be an important item. Upkeep, too, is a further contingency to provide for. This may prove to be much or little, according to the type of plant, the care used in handling and operating, and the character of the fuel used.

### Gas-Producer Plants.

In considering the installation of a gas-producer plant much the same thing applies in the matter of cheap fuel as with a low-pressure steam boiler. Whilst it is admitted that anthracite, if procurable without difficulty, and at a reasonably cheap price not too far from a pit-head, is the ideal fuel from every point of view, it should not be taken for granted, because the reverse may happen to be the case, that such a condition will rule this type of plant out of court, or yet rob it of the economic advantages which it may possess. From a calorific standpoint the lowest-grade fuel it is possible to use in a gas producer, viz., wood refuse—chippings, shavings, sawdust, etc.—may possess at most but half the number of heat calories derivable from anthracite. Yet, if the former fuel happens to be obtainable in unlimited quantities, as might well happen, and at a price little above the cost of removal and carting, again a quite feasible probability, then the provision of a gas producer, of sufficiently extra capacity to deal with the larger quantities of material involved, might be quite an economical proposition. Or a producer constructed to consume bituminous fuel, at, perhaps, half the cost of anthracite, would be worth serious consideration.

### Waste Refuse as Fuel.

But in the writer's opinion there is not in this country a sufficiently wide use made of many of our waste commodities, notably wood refuse, this particularly being true at the present time, when coal of any kind is so high priced. True, the use of these low-grade fuels involves a departure from standard producer design, and requires a much more efficient and larger type of purifying apparatus to eliminate dust and impurities than when coal is the fuel used. But these considerations are more than outweighed by the low cost of the gas produced, and large plants specifically designed to deal with the refuse from several British factories and mills, which have been inspected by the writer, are giving highly efficient and most economical results.

### Use of Town's Gas.

Then there is the case for the use of town's gas. Many users of power, that is to say, small and medium-sized users, are readily prepared to drop whatever economy might be effected by the use of a gas-producer plant, because in their opinion there is, by the use of town's gas, much less risk of breakdown and a loss of continuity. In many instances this opinion is a perfectly tenable one. But there is this much to be said for it, that, generally speaking, such opinions are found to be induced by the relatively low price of town's gas prevailing. Given instances where the price of gas exceeds, we will say, 3s. 6d. per thousand, and these opinions are then more than outweighed by the economy made possible by the use of a gas-producer plant.

Of course, it will be understood that the considerations affecting each and every problem in power generation and transmission must be based primarily upon local influences. To attempt to lay down a hard and fast rule, which shall apply equally to each and every kind of problem involved, and every kind of industry, would be not only impracticable, but absurd. A gas-power installation might, under certain circumstances, be admirably adapted for the needs of a certain industrial concern, in so far as the power requirements are concerned, and, furthermore, show favourably low working costs; but for all-round efficiency, and the meeting of the incidental needs peculiar to the industry in question, it might well happen that a modern steam-power plant, efficiently designed, and embodying

comprehensive features, would by comparison show the highest thermal efficiency.

Therefore it must always be what is termed special circumstances that govern the selection of a power generator, and the fact of ignoring these may often result in the installing of a plant utterly unsuitable for the conditions which obtain.

## BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

*(Continued from page 131.)*

HEAT TRANSMISSION.

### Circulation in Water-tube Boilers of the Stirling Type.

In the group of water-tube boilers described in our last article the tubes are only inclined to the horizontal about 15 deg.

Water is fed into the distribution box B in the back steam drum A in such a manner as to ensure an equal feed to all the down tubes. From this back drum the path of the water is as follows:—

1. Down the fourth bank of tubes to the back mud drum.
2. Up the third bank of tubes to the intermediate steam drum.
3. Down the second bank of tubes to the front mud drum.
4. Up the first bank of tubes to the front steam drum.
5. Through the top water-circulating pipes D to the intermediate steam drum, and then repeating the path described in Nos. 3, 4, and 5 until water is evaporated.

It will be noticed that in this boiler there is no direct water connection between the intermediate and back steam drums, consequently all the water must pass down the back bank of tubes. As these tubes are almost vertical, and are exposed to the comparatively cool flue gases, it follows that scale-forming matter in the water will be precipitated here, and easily pass down into the mud drum

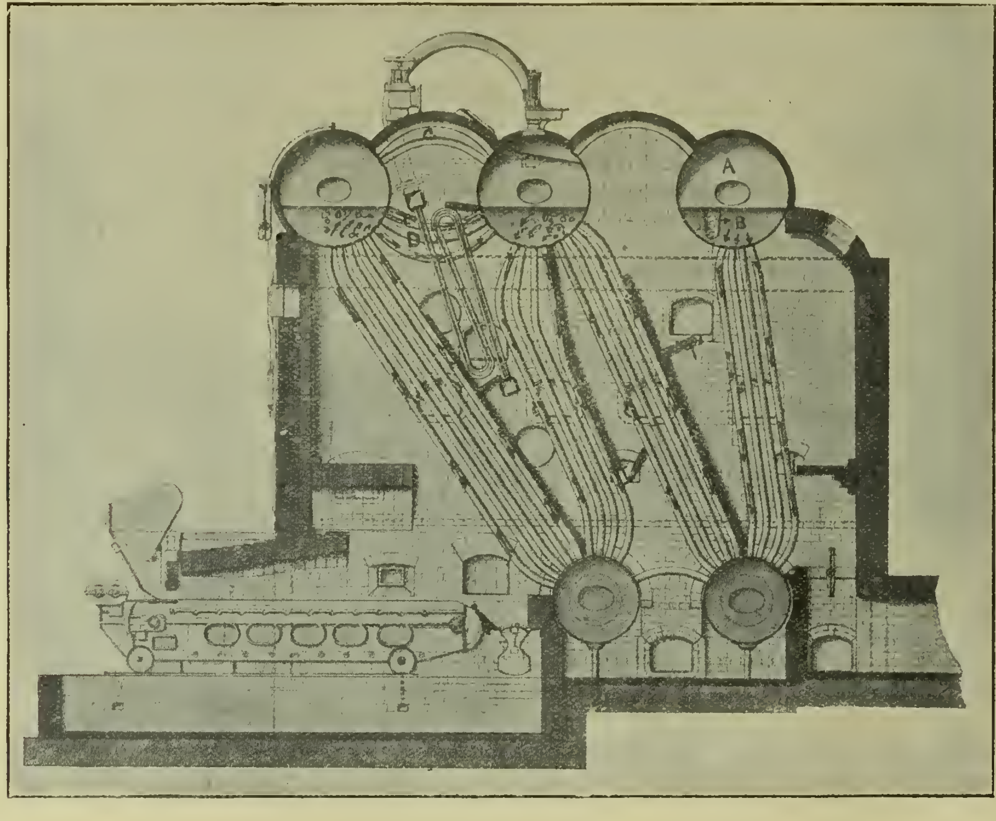



Fig. 85.—Boiler-House Efficiency.

Another group of boilers have the tubes more nearly vertical. The claims made for this latter type as against those with the more horizontal tubes, are:—

1. The circulation is more vigorous.
2. The release of the steam from the plate surface and its separation from the water is much easier.
3. There is less tendency for scale and dirt to accumulate on the surfaces.

The Stirling boiler is probably the best-known example in this group of water-tube boilers, and is shown in section in Fig. 85.

without adhering to the tube surface. The mud drum is protected from intense heat, and therefore makes an excellent settling chamber.

A point is made in this boiler that the steam supply is taken from either the intermediate or back steam drum. As the maximum steam production will take place in the front bank of tubes, and as this steam will pass into front drum through pipes C into the intermediate drum, the steam becomes heated and dried in its passage as the tubes C are exposed to hot gases. Consequently the claim is made that this boiler produces dry steam. At heavy loads, however, care is required in working this boiler if priming is

to be prevented. The writer has had experience with a large battery of Stirling boilers where, until the correct working conditions were found, priming took place at an alarming rate.

The boiler has adequate steam and water spaces, and has therefore a large disengaging surface for the steam. Also it will be noticed that the hottest gases come in contact with the tubes containing the hottest water, and the cooler gases with the tubes containing the coolest water. This, of course, gives the most efficient arrangement.

It is interesting to note that with this boiler the ratio

$$\frac{\text{Normal evaporation per hour from and at } 212 \text{ deg. Fah.}}{\text{Heating surface.}} = 4\text{lbs.}$$

### Circulation in the Sinclair and Woodeson Boilers.

Two other well-known types of water-tube boilers in this group are the Sinclair and the Woodeson boilers. A section of the former boiler is shown in Fig. 86.

It will be seen that the difference between this boiler and the Stirling is that each bank of tubes has its own separate steam and mud drums, and also that all tubes are straight.

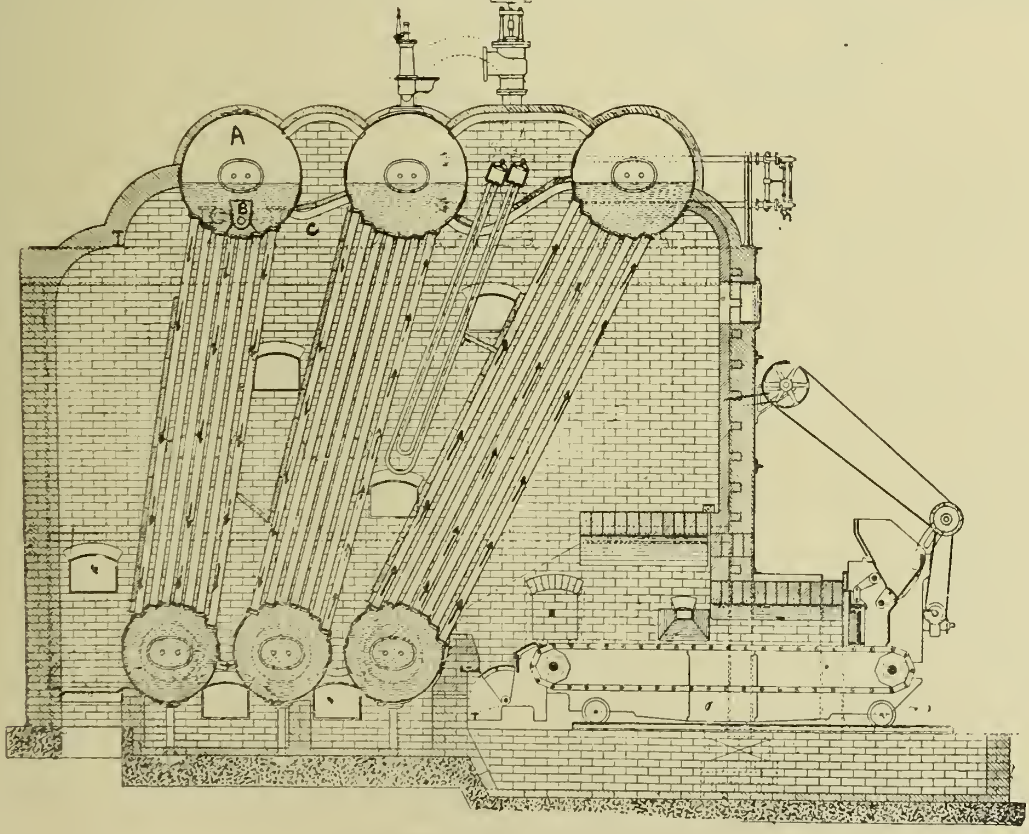



Fig. 86.—Boiler-House Efficiency.

Water is fed through the distributing pipe B in the back drum A; in such a manner as to ensure even water feed to all the tubes.

The water passes down the back bank of tubes, which are nearly vertical, as in the Stirling boiler. Any scale-forming material is precipitated and falls into the mud drum.

It will be seen from the figure that in this boiler there is a water connection between the back and the intermediate steam drums, so that the feed water can pass directly into the latter drum.

In the middle bank of tubes, therefore, it is almost certain that a variable circulation takes place, and that the back tubes of the bank will often act as downcomers whilst the front tubes are acting as risers.

Between the intermediate and front mud drum there is a much larger water connection, thus ensuring sufficient supply of water to the front bank of tubes to keep the circulation as shown by the arrows.

As each tube is almost vertical, perfectly straight, and enters the steam and water drums without any kind of interruption there is perfect steam release, and no resistance to be overcome in moving the water through bends.

### Circulation in the Garbe Water-tube Boiler.

Another boiler in this group, and in which each bank of tubes has its own steam and mud drums is shown in Fig 87. This boiler, known as the Garbe boiler, is used largely for central electric stations on the Continent.

It will be seen that there are only four drums in this boiler, and that large-section straight tubes connect the two steam drums, and also the two water drums.

The circulation in this boiler is quite simple, and is exceedingly vigorous. Feed water enters the back drum, passes down the vertical back bank of tubes into the bottom mud drum. From here is passes to the front mud drum, then up the front bank of tubes into the front steam drum. The water continues this path until evaporated.

The advantages of scale depositing in back mud drum, of large and free steam release area, can also be claimed for this boiler.

As a matter of fact, this boiler probably comes nearer to the ideal of the U-tube—which was shown to be the correct principle on which to arrange the circulation—than any other of the water-tube boilers.

As shown in Fig. 87, the steam supply is taken from the front steam drum. Now the rising mixture of water and

steam coming up the front bank of tubes into the front drum will cause considerable water movements in the latter, and the tendency will be for wet steam to be supplied. A

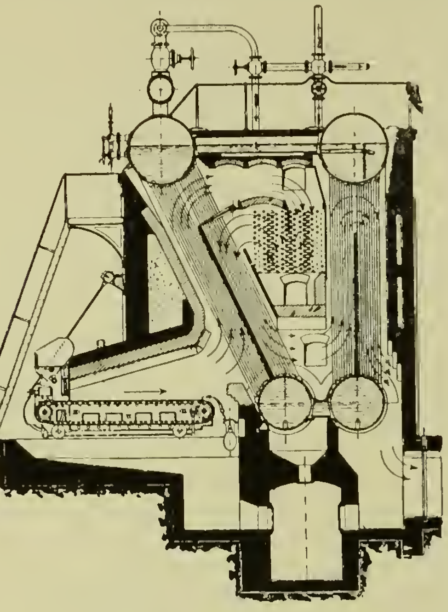


Fig. 87.—Boiler-House Efficiency.

much better arrangement would be to take the steam supply from the back drum when the water movements are downwards.

*(To be continued.)*

## PRODUCER GAS.*

By H. E. Copp.

### Coke Oven Gas.

Many large installations on this system have been introduced in this country during recent years. The methods of working are much the same as those employed in the production of ordinary coal gas. The temperature of carbonisation is usually considerably lower with a view to increasing the yield of residuals. The yield of gas is generally about 9,000 cubic feet per ton, and the calorific power about 330 B.Th.U. The leaner portion of the gas is used for heating the settings after being treated for the extraction of tar, ammonia, and liquid hydrocarbons. The gas and secondary air are pre-heated in flues in much the same way as in an ordinary regenerative retort setting. The richer portion of the gas is generally used for driving the large gas engines for providing the blast for iron smelting and the generation of electricity for general purposes.

### Water Gas.

Water gas was invented by Prof. Lowe, of U.S.A., in about 1874. Assuming the generator to be filled with incandescent coke, a strong blast of air is introduced, forming (as in the case of the simple producer) $CO_2$, which is further reduced to CO, the coke is thereby raised to a high state of incandescence. After blowing for about three minutes at a pressure of about 20 in. water column, steam, preferably superheated, is driven through the coke—the resulting gas having approximately the following percentage composition: H, 49·17; $CH_4$, 0·31; CO, 43·75; $CO_2$, 2·71; N, 4·06.

With this process a large quantity of heat is naturally lost during the "blow" owing to the excessive production of producer gas; this loss may be reduced in two ways: (1) By utilising the heat for the production of oil gas; (2) by reducing the thickness of the bed of fuel and using a much stronger blast, so that the double reaction resulting in the production of CO is more or less prevented, and the waste gases may contain more $CO_2$, which is an incombustible gas, and less CO, a valuable fuel gas. This system was invented by Carl Dellwik, and the first plant in an English gasworks was installed by the author's colleague and predecessor at West Bromwich, Mr. Thomas Glover, M.Inst.C.E., in 1901, but completed under the author's régime; 70,000 cubic feet of gas were produced by this plant per ton of coke used, the calorific power being 300 B.Th.U. gross. In those days of high illuminating power a large amount of enrichment was needed. This was supplied by benzol vapour, which was introduced into the gas. A Peebles oil-gas plant was subsequently added, by which some remarkable enriching values were obtained, reaching 10 candles per gallon of oil per 1,000 cubic feet. The extra cost of fuel, however, left little margin of profit.

The cost of the unenriched or "blue" water gas was about 4½d. per 1,000 cubic feet. At about that time a gas engine was installed for the generation of electricity for general works purposes, which was designed for using blue water gas. The cost of the generation of current was so low that it attracted the attention of many eminent engineers and professors. In the author's opinion much will be accomplished in the future on this system. Owing to unforeseen events, it became necessary to instal a new and larger water gas plant. The Dellwik plant was, therefore, replaced with a carburetted water gas plant by Messrs. Humphreys and Glasgow. In this system the highly-heated gases leaving the generator during the "blow" pass into the carburetter and thence through the superheater, both of which are filled with chequered brickwork, which is raised to a high temperature.

During the "run" or period of gas production, oil is sprayed into the carburetter in quantities necessary to produce any desired illuminating power. The oil vapour passes forward to the superheater intimately mixed with the water gas where it is "cracked" or split up into permanent gas. The average percentage composition of carburetted water gas is: $CO_2$, 3·11; CO, 31·52; $C_nH_2$, 8·48; $CH_4$, 15·69; H, 32·61; O, 0·89; N, 7·80.

### Dowson Gas.

This fuel gas is produced by forcing an admixture of steam and air through incandescent coke or anthracite. The process is, therefore, continuous. A small gas holder is generally used in connection with this system, the rate of production being controlled by means of a chain or rope connected to the holder, which is made to operate the steam and air regulating valves to the generator. The calorific power of Dowson gas is about 140 B.Th.U., the percentage composition being approximately: $CO_2$, 4·8; CO, 27·6; $CH_4$, 2·0; H, 7·0; N, 58·6.

### Suction Gas.

In this system there is no gas holder or boiler. A small chamber surrounding the generator is kept filled with water at a constant level, which is converted into steam by the heat of combustion of the coke or anthracite with which the generator is filled. The suction of the piston during the

* From a paper read before the Stoke-on-Trent Engineers' and Engineering Students' Association, February 24th, 1917.

admission stroke draws air charged with steam into the bottom of the producer; the gas thus produced is drawn through a scrubber for removing the dust, and thence into the engine cylinder. The heat losses in this system are greatly minimised, very little radiation taking place from the walls of the generator, as the greater part is absorbed by the water surrounding the hottest portion. With the generator in perfect condition for gas making, the engine may be run at a very low cost, but the gas, which should be about 145 B.Th.U., naturally varies with the quantity of ash present in the generator. Therefore in practical working over long periods the economy factor is much reduced. It is also found that the pistons and liners of the engines have to be frequently renewed on account of the action of the impurities and fine dust in the gas. There are a number of devices for mechanically removing the ash from gas producers. One of the best, and probably one of the first, was invented by Mr. J. W. Hartley, of Stoke-on-Trent, in 1893, and possesses many features of interest.

### Mond Gas.

This system is probably the most scientific and economical method for the production of fuel gas which has yet appeared. The principle involved necessitates the employment of large units, of which many have been erected in this county, one of the largest probably being that installed at the Birchenwood Collieries. The Mond Gas Company, whose works are situated at Dudley Port, supply a number of towns in the immediate neighbourhood through an extensive system of large steel mains. The objects aimed at are to utilise the cheapest grades of bituminous small coal or slack, and to recover as much as possible of the nitrogen in the coal as ammonia. The recovery of sulphate of ammonia is about 90 lbs. per ton of coal, equivalent to about 70 per cent of the nitrogen. The yield of gas is usually about 140,000 cubic feet per ton, the calorific power being about 145 B.Th.U.

The main feature of the Mond process is gasification at a low temperature, the heat being conserved by means of a regenerator to the fullest possible extent. The generator consists of a double wrought-iron shell, cylindrical above, and cone shaped at the bottom, which is water sealed, the inner shell being lined with firebrick. At the top is an interior bell-shaped vessel into which the fuel is fed and partly carbonised by the hot gases, the tar being converted into permanent gas, which passes downwards to the edge of the vessel into the generator proper. After being drawn or injected through the regenerator surrounding the offtake pipe the air and steam blast passes to the base of the generator. The gas leaves the generator at a temperature of about 280 deg. Cen. and enters the washing and cooling chambers, which are usually fitted with a power-driven water atomising apparatus; steam is formed at a temperature of about 90 deg. The mixture of steam and gas then enter the acid tower in which the ammonia is extracted by means of a 4 per cent solution of sulphuric acid. The liquid is recirculated until it has attained a strength of about 38 per cent of sulphate of ammonia. The gas is then led to the cooling tower, in which there is a descending current of cold water, and passes thence to the mains. The hot water, on reaching the bottom of the cooling tower, is pumped to the top of another tower, through which the air for the producer is blown. The system thus supplies an example of scientific heat exchange, and the efficiency is such that nearly 80 per cent of the heating value of the fuel is recovered in a useful form, and is therefore much higher than in any other type of producer.

### Blastfurnace Gas.

Until within recent years this valuable gas, of which about 30 per cent is combustible, was partly utilised under boilers for generating steam and the remainder wasted. Its composition is about 12 per cent of $CO_2$, 25 per cent to 30 per cent CO, a small percentage of $CH_4$, and about 3 per cent of hydrogen, the remainder being nitrogen. About 160,000 cubic feet of gas is produced per ton of pig iron produced, the calorific power being about 112 B.Th.U. If blastfurnace gases are used for steam raising in boilers it is estimated that 22 per cent of the total gas produced is available for purposes other than heating the blast, driving the blowing engines (by steam), etc., whereas if gas engines are employed as much as 50 per cent is available for other purposes. In modern gas engines from 1,200 H.P. to 1,400 H.P. can be generated per cylinder. It is estimated that 1,000,000 surplus brake-horse power could, in this country, be obtained from blastfurnace gas by the use of these large gas engines. In addition to this, the hot exhaust gases from the engines would for every 5,000 B.H.P. produce sufficient steam to develop 600 B.H.P. in an efficient steam turbine. It is therefore a matter of national importance that producers of pig iron should be encouraged to utilise their fuel to the fullest possible extent. Fuel, of which such a vast proportion has been wasted in the past through lack of enterprise and scientific application, must always be regarded as our most valuable asset as a nation.

## ALUMINIUM SUPPLIES: MINISTRY OF MUNITIONS ORDER.

The Ministry of Munitions has issued an Order, dated February 17th, requiring all persons to send in to the Director of Materials A.M.2(H), Hotel Victoria, Northumberland Avenue, London, S.W., in the first seven days of each month, commencing in March, monthly returns of—

(*a*) All aluminium held by them in stock, or otherwise under their control, on the last day of the preceding month; (*b*) all aluminium purchased or sold by them for future delivery and not yet delivered on such last day, together with the names of the sellers to or purchasers from them; (*c*) all aluminium delivered to them during the preceding month; (*d*) all aluminium scrap or swarf produced by them and/or issued from their works during the preceding month; and (*e*) all contracts or orders existing on the last day of, or entered into during, the preceding month requiring for their execution the use of aluminium, specifying the purposes thereof.

Notwithstanding the above, no return is required from any person whose total stock of aluminium in hand and on order for future delivery to him has not at any time during the preceding month exceeded 56 lbs.

For the purpose of this Order the expression aluminium shall mean: Aluminium and alloys of aluminium, unwrought and partly wrought, including ingots, notched bars, slabs, billets, bars, rods, tubes, wire, strand, cable, plates, sheets, circles, strip; aluminium scrap and swarf, aluminium alloy scrap and swarf, remelted aluminium scrap and remelted aluminium alloy scrap and swarf; and granulated aluminium, aluminium powder, "bronze," "flake," and "flitter," or any of these.

Note.—Attention is drawn to the fact that under the Order made by the Minister of Munitions on December 2nd last, whereby Regulation 30 (A) of the Defence of the Realm Regulations was applied to aluminium as above defined, all dealing, or negotiations for dealing, in aluminium

without a permit as specified in that Regulation, is illegal, and an offence against the Defence of the Realm Regulations.

## INSTITUTE OF METALS.

A special feature of the forthcoming spring meeting of the Institute of Metals, to be held on March 21st and 22nd, will be a general discussion on metal melting, a subject which hitherto has received very little attention from the scientific societies. It has now assumed great national importance, since vast quantities of fuel—solid, liquid, and gaseous—are used in metal melting, particularly for munitions making. Economies in the use of these fuels in the metal industries are generally realised to be possible, but the lack of comparative data has often hindered the adoption of the most efficient means of metal melting. The Institute of Metals is very fortunate in having as its president, who will preside over the discussion, Sir George Beilby, LL.D., F.R.S., the head of the new Government Board of Fuel Research. At the forthcoming meeting a series of communications will be made bearing on all phases of the question of the melting of the non-ferrous metals, whether by high-pressure or low-pressure gas, coke, oil fuel, or electricity. Papers to be contributed include the following: "Metal Melting as practised at the Royal Mint," by W. J. Hocking; "Coal Gas as a Fuel for the Melting of Non-ferrous Alloys," by G. B. Brook; "High-pressure Gas Melting," by C. M. Walter, M.Sc.; "Contribution to Metal-Melting Discussion," by H. M. Thornton and H. Hartley, M.Sc.; "An Electric Resistance Furnace for Melting in Crucibles," by H. C. Greenwood, D.Sc., and R. S. Hutton, D.Sc.; "Ideals and Limitations in the Melting of Non-ferrous Metals," by Carl Hering; "Metal Melting in a Simple Crude Oil Furnace," by H. S. Primrose. In addition to the metal melting discussion, several important communications bearing on other phases of metallurgical work will be presented at the meeting, amongst which may be mentioned the following: "The General Properties of Stampings and Chill Castings in Brass of Approximately 60/40 Composition," by Owen W. Ellis, B.Sc.; "Machining Properties of Brass," by Owen W. Ellis, B.Sc.; Surface Tension and Cohesion in Metals and Alloys," by Sydney W. Smith, B.Sc., A.R.S.M.; "Aluminium Production by Electrolysis: A Note on the Mechanism of the Reaction," by R. Seligman, Ph.Nat.D.; "Annealing of Nickel Silver (Part II.)," by F. C. Thompson, D.Met., B.Sc. (subject to being completed in time). The seventh annual May lecture will be given at the Institution of Civil Engineers, Great George Street, Westminster, S.W., on Thursday, May 3rd, 1917, at 8-30 p.m., by Professor W. E. Dalby, M.A., F.R.S., on "Researches made possible by the Autographic Load-extension Optical Indicator."

In connection with the Spring meeting of the Institute an election of members, which will probably be on a more extensive scale than usual, owing to the Institute having removed to larger premises, will be held. Particulars of membership can be obtained from the secretary, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, S.W. All candidates for membership whose applications are in the secretary's hands before March 14th will be entitled to take part in the proceedings at the London meeting. Members elected at the forthcoming meeting will have the privilege of membership, not for the usual 12 months, but for the extended period ending June 30th, 1918. The present membership of the Institute is 660, a record total.

## STORAGE BATTERIES.

By F. Ashton.

### Their Economy.

Great economy often results from the use of storage batteries in conjunction with power and lighting installations, but unless a battery receives proper attention it is liable to involve much trouble and expense. The knowledge requisite to work a battery properly is easily acquired even by those who have had no electrical training, for it is simply a matter of adhering rigidly to certain definite rules. Many good batteries have nevertheless been quickly ruined by careless operators, and it cannot be emphasised too strongly that unless the makers' instructions are going to be adhered to battery installations are best left alone.

### Study the Makers' Instructions.

Every accumulator manufacturer has his own pet theory as to how the cells should be treated, and when an engineer takes over a new battery he should carefully study the makers' instructions before the cells are put into use. As a rule the makers send out experts who are ready and willing to give advice, and when a maintenance contract is entered into the makers' engineers examine the cells periodically. Batteries are, however, sometimes left to the mercy of people who know little, and care less, about electrical affairs, and when the capacity of the cells falls off as the result of improper treatment the makers are blamed. Others, though anxious to obtain the best results and to keep the cells in good condition, fail to recognise the importance of adhering rigidly to certain recommendations. One very common error which inexperienced people make is that of excessively overcharging batteries. Whilst it is important that accumulators should receive the proper amount of charging, excessive overcharges are distinctly to be avoided. Excessive overcharging shortens the life of the plates, gives rise to unnecessary rapid accumulation of sediment at the bottom of the cells and produces excessive evaporation of the electrolyte. What the makers recommend in the way of overcharges should be rigidly adhered to, otherwise a battery may prove an unprofitable investment.

### Batteries for Lighting Purposes.

Batteries for lighting purposes are in many cases given regular charges when the cells are from half to one-third full and overcharges at periods depending upon the frequency of the regular charges. If, for instance, a battery receives a regular charge daily, an overcharge of the specified duration might be given once a week. Batteries used in conjunction with reversible boosters for steadying the loads on power plants are often given an overcharge at the end of each day's work, and this charge is continued for about ten minutes after the cells are full. An additional charge is also frequently given once a week, and this charge is continued until the cells show indications of being in a good condition. The voltage of the main part of the battery, which does not include the regulating cells and the specific gravity of the electrolyte, give very fair indications of the general conditions of the cells. When a battery is new the voltage per cell at the end of an overcharge should be at least 2·5 volts per cell, but this decreases with the age of the accumulators and with the temperature of the electrolyte. At one time accumulator makers paid little attention to the temperature of the electrolyte, but it is now recognised that when measuring the voltage of a battery the temperature should be taken into account. At temperatures above 60 deg. Fah. the pressure is lowered

and increased with lower temperatures. During the charge sulphuric acid is driven out from its combination with the plates, and the specific gravity of sulphuric acid being nearly twice as great as that of water, that of the electrolyte rises accordingly. The specific gravity is read by a hydrometer, a lead-weighted glass float having a slender graduated stem, resembling that of a thermometer. As the density of the electrolyte decreases the hydrometer sinks deeper into the liquid; whilst when the density increases it floats higher, and in each case the specific gravity is indicated by the graduation on the stem of the hydrometer, which is opposite the surface of the electrolyte. The specific gravity and voltage of individual cells are tested at intervals specified by the makers, and the readings are entered upon specially-printed forms or in books. All the cells should be numbered so that those that show low readings can easily be kept under observation. The voltage of individual cells is tested with a small hand voltmeter with a low reading scale. The correct specific gravity for the electrolyte is not the same for all makes of accumulators, but at a normal temperature of 60 deg. Fah. it is usually between 1·205 and 1·215 when the cells are fully charged. The correct value is always given on the makers' instruction sheets, and those in charge of battery installations should work accordingly. By taking readings of the voltage and specific gravity, faulty cells are soon located, for the chief symptoms of cells being in an unhealthy condition are low readings of this kind. Moreover, when on charge, faulty cells will in all probability fail to gas or will gas less vigorously than the others. When healthy cells are fully charged bubbles of gas rise freely in the cell, and give the liquid the appearance of boiling. The current has then completed its work upon the plates and is decomposing the electrolyte, and when this occurs it is time for the charge to be stopped.

### When Fully Charged.

When fully charged the positive plates of healthy cells have a rich chocolate colour, and the negative plates a lead-grey colour, and these colours afford one method of ascertaining whether cells are in a good condition. When a cell gets into a low state the cause should be located and remedied at the earliest possible moment. Not infrequently the trouble is due to active material having become loose and lodged itself between the plates, thus short-circuiting the cell. For locating trouble of this kind special low-voltage inspection lamps are supplied which enable the interiors of cells to be inspected with the greatest of ease. Another trouble which, however, only results, as a rule, from improper treatment is known as sulphating. If a lead sulphuric acid battery be charged or discharged at an excessive rate or be allowed to stand in a discharged condition the acid attacks the plates and forms a white coating when the cells are said to be "sulphated." This coating is insoluble and a non-conductor; consequently it removes from action those parts of the plates it covers. When not too excessive, sulphating may be removed by repeated charging and discharging. Repeated charging and discharging is, in fact, always necessary to bring a weak cell back to its normal state when the cause of the trouble has been removed. But it is obviously a wrong policy to keep on overcharging a whole battery for the sake of one or two weak cells, for this will injure the cells that are in good condition. If a cell that has been suffering from some ailment does not recover after the whole battery has received, say, two or three weekly overcharges, other methods should be adopted. One method is to disconnect the faulty cell from the battery when the latter is discharging, and to connect it up again when the battery is charged. Sometimes, however, particularly in the case of large batteries, the plates of all the cells are burnt together, when the above scheme is, of course, impracticable. Under such conditions it is customary to use a small milking booster, which is directly connected across faulty cells by special leads. By adjusting the strength of the field of this booster, the charging current can be regulated to a nicety, and the cell can be charged as long as is necessary without interfering with the other cells in any way. When a faulty cell has fully recovered itself it will "gas" freely with the others, and the plates will have their proper colours. Moreover, the specific gravity and voltage will, of course, be normal.

*(To be continued.)*

## CHIMNEY AND MECHANICAL DRAUGHT.*

By E. R. Fish.

Boiler and furnace practice has changed to such an extent within the last few years that the generally accepted ideas of a few years ago are now largely obsolete. Most large and many small plants are now equipped with mechanical stokers of some one of the numerous types, particularly in those centres where room is limited and smoke-abatement laws are enforced. While chimneys alone are still largely depended upon to produce the draught necessary for the combustion of fuel, the tendency is strongly towards supplementing them with mechanical equipment. The effective draught, or that which is used for getting the air through the fuel bed, may be produced in three general ways: First, by the natural draught of the simple chimney; second, by induced draught; third, by forced draught. But when the whole of the boiler installation is considered several combinations of these may be desirable or necesary.

Where natural draught alone is depended upon, it must be of sufficient intensity to overcome all the resistances from the top of the stack to the ashpit door. With a given height of stack the available draught is practically fixed, although it varies with the temperature, state of the weather, barometer, etc. A chimney of moderate height cannot supply a sufficient draught to maintain what is now looked upon as a high rate of combustion. For conditions under its maximum, natural draught is easily controllable by means of dampers so that the furnace conditions can be maintained at the most economical point. The principal recommendations of a chimney are its simplicity of operation, its need for comparatively little care and attention, and its being always on the job. Its thermal efficiency is low, but the other advantages offset that in cases where high draught intensity is not needed.

To attain a strong draught by means of a chimney is prohibitive because of the great height involved and the cost. It is therefore necessary to turn to other arrangements, such as an induced-draught system, wherein the suction is created by a fan. The nature of this draught is exactly the same as chimney draught, but it has the advantage of being susceptible to accurate control so that the furnace needs may be readily met. It makes possible the installation of economisers to lower the temperature of the escaping gases and to effect a saving in fuel.

At the present time a combination of forced draught and either natural or induced draught is being used more and more. Many of the later stokers are operative only with forced draught, and are designed for high rates of

* Abstract of paper read before the Eleventh Annual Convention of the Smoke Prevention Association, St. Louis.

combustion. Forced draught alone is not a good arrangement, for the reason that it creates a plenum throughout practically the whole installation, and makes leaks outwardly through the interstices in the setting likely. By providing a stack of proper height or an induced-draught fan the necessary suction draught may be supplied to overcome the resistance of the gas passages, leaving the forced-draught fan to supply the pressure necessary to overcome the resistance of the fuel bed. This produces that desirable condition, balanced draught, the pressure above the fuel bed being practically zero, or preferably a little on the minus side—that is, the draught gauge should show a slight vacuum.

The amount of fuel burned under a boiler largely determines the amount of steam that will be generated. There is, of course, a more or less well-defined relation between grate area and heating surface, although this varies between rather wide limits. The heating surface of boilers in many instances is being worked far harder than was supposed possible a few years ago. This has been brought about by the introduction of furnaces capable of high rates of combustion, with the result that the temperatures of the escaping gases are too high for the proper economy, rendering necessary the use of feed-water economisers of proper capacity. Such installations are economical as to heat absorption, in interest charges resulting from a smaller investment, and in floor space. The great objection to these types of installations is the complication due to more operating parts from which the plain chimney of our forefathers is entirely free.

The need for a high intensity of suction draught in connection with forced draught, when high capacities are used, is not generally recognised. When it is realised that the draught required to cause the flow of gas increases as the square of the velocity, it will be seen that this is important. If ½ in. in the uptake is sufficient for satisfactory operation at one capacity, doubling the capacity at least doubles the quantity of gas, which means that the gases must flow twice as fast, assuming that the furnace efficiencies and temperatures are the same in both cases. Theoretically, therefore, it would take four times as much draught, or 2 in. as measured by the water column. It is on this rock that many engineers have come to grief, in that the attainment of their desire to get a high capacity out of their boilers has not been possible, because after reaching a certain rate of combustion there is a plenum created in the furnace and through the setting, resulting in furnace gases coming out through the numerous interstices that inevitably exist, owing to the insufficiency of the available suction draught to pull the gases through the boiler and breeching.

The balanced condition is highly advantageous in another way. The greater the difference in pressure between the inside of the setting and the outside, the greater the amount of air drawn in through any cracks or openings that exist, as well as through the porous setting. The less these differences in pressure, the less air will be drawn through. All such air is only detrimental, and can do no possible good. Every effort should be made to prevent these leakages if the boiler plant is to be run at its highest efficiency.

It is now common to enclose the entire setting in a sheet-iron casing, carefully fitted and made as tight as practicable. Special preparations for coating the outside of brick walls and stopping up cracks are on the market, the goal of all being the same—the exclusion of unnecessary and objectionable air from the interior of the setting.

To attempt to force a grate to burn more fuel than the draught available makes possible, results inevitably in waste and inefficiency through the formation of carbon monoxide instead of carbon dioxide, so that where draught cannot be increased beyond a certain point care must be used not to try to force a higher rate of combustion than can be efficiently maintained.

Every set of boiler and furnace conditions has its most economical point of operation, which cannot be exceeded with satisfactory results; but this is true within much narrower limits of simple chimney draught than with either forced or induced draught, with the accompanying possibility of widely varying adjustments.

The tendency of modern boiler practice is decidedly towards setting boilers well above the grates so as to give a large combustion space. It is pretty generally recognised that the heat of combustion should all be freed before any of the gases come in contact with the heating surface of the boilers, which in relation to the gases is the cooling surface. A large, high furnace and combustion chamber are essential to attain this end, in addition to which the resistance to flow is minimised.

It is important that the breeching should be as short and direct as possible. Square turns of any sort should be avoided, as all such increase the resistance. The well-known principles governing the flow of water apply almost as universally to the flow of gases. Easy curves should be provided, and all corners and dead spaces avoided. Areas must be properly proportioned to the volume of gases to be cared for, and this is particularly true in those plants where high overload capacities are contemplated.

Modern boiler practice seems to indicate that for the larger and more important plants at least something more than ordinary chimney draught is needed. Where simplicity of installation is paramount, simple chimney draught cannot be improved upon. As applying to the aevrage plant throughout the country, use every means to prevent air from entering the gas passages other than through the fuel bed; see that the loss of draught due to restricted, improperly designed, and obstructed flues is reduced to a minimum, so that the boiler and furnace will be in condition to give the maximum efficiency.

## FEED WATER FOR STEAM BOILERS.*

By Arthur C. Scott and Prof. J. R. Bailey.

In recent years the value of a critical analysis of production costs and operating efficiencies has become prominent in the business of manufacturing, and since water is necessary for the operation of nearly every industrial establishment, its *quality* is receiving more attention than formerly. The plant owner is rapidly modifying his views heretofore concerned only with the available quantity, because of the important factor in the operating cost due to the use of water unsuited to the service required. This is especially significant in steam making.

No general source of water supply, whether lakes or ponds of surface water, rivers, or wells of varying depth, is free from impurities obtained either from filtration through the earth, or from the air, or from both. Water from lakes or large reservoirs is ordinarily most satisfactory for boilers, since it is chiefly rain water and surface drainage, and the suspended matter has had opportunity to settle. Under conditions of a long drought, however, as the reservoir capacity is reduced, the organic

* Abstract of paper read at the annual meeting of the American Society of Mechanical Engineers, New York, December, 1916.

matter from algal growth and other sources may have an appreciable effect upon the quality of the water.

River water is more or less variable in character, depending upon the location or extent of the watershed or drainage basin and upon the rainfall. Slow-moving rivers may carry a large amount of mud, some of which settles out readily, while the red or yellow mud will generally remain in suspension a long time unless some coagulant like sulphate of alumina is used. A river frequently picks up considerable organic matter, which by decomposition forms organic acids that corrode boiler metal. The character of a drainage area of a river will affect the character and content of dissolved mineral matter in the water, and this will vary more or less with the season of the year and may vary from day to day part of the time. Well water varies in quality with the location and depth of well and with the rainfall. Water from deep well sources is usually low in organic matter, but contains mineral constituents dissolved by the water in passing through the earth.

### Boiler Failures and Losses Due to Scale.

Reports show an increased number of dangerous defects in boilers from year to year due to scale, corrosion, priming, etc. Aside from the dangerous condition of a "scaly" boiler, scale also means fuel waste, ranging according to the thickness from 2 per cent for $^1/_{64}$ in. thickness, to 90 per cent for $\frac{3}{4}$ in. as a general average. Other troubles through scale are clogged feed pipes and water and steam gauge connections, and valves prevented from completely closing.

### Water-softening Processes.

The common methods of reducing scale troubles are: (*a*) Two types of cold processes for the actual softening of water; the intermittent originating with Clark in 1841, and the continuous invented about 1867. (*b*) The hot process. (*c*) Live-steam purifiers. (*d*) Boiler compounds.

For very large plants where several hundred thousand gallons per day are used, a considerable expenditure is justified for tanks and mechanical equipment for the cold process of purification, which is fundamentally a treatment of the water with proper amounts of milk of lime and soda ash. These cold processes perform their chief service in softening water for locomotives, and in large plants where water is used in considerable quantities in connection with jet or barometric condensers, or where it must be softened for other purposes than boiler feed alone.

The hot process is particularly desirable for plants where exhaust steam is available. Purification of the water is partly obtained by heating to the approximate boiling point, but sufficient soda ash is added to satisfy the alkaline earth sulphates and chlorides and any acid present. The essentials are heat and soda, and the whole scheme is virtually embraced in the ordinary operation of an open-type feed-water heater, with the introduction of soda ash into the hot water.

Live-steam purifiers are useful as partial purifiers, but are always subject to boiler pressure, waste some heat, must be placed higher than the boiler level, and frequently give trouble from water-hammer.

Boiler compounds are more or less palliative in their action, and produce results by (*a*) acting as chemical reagents combining with the scale-forming impurities, breaking them up and precipitating them as sludge; (*b*) acting mechanically on the precipitated scale-forming matter and entrapping it as it is precipitated from solution before it has formed a hard adherent scale. Examples of materials in use under (*a*) are soda ash, caustic soda, trisodium phosphate, sodium fluoride, and compounds of tannin; and under (*b*) gelatinous or starchy materials, such as ground bones, hoofs, horns, slippery elm, and potatoes.

Boiler compounds are to be recommended for use only in small plants whose capacity will hardly justify arrangements to purify the water before it enters the boiler. The steam boiler should be used primarily for generating and storing steam energy, not as a precipitating tank. If it must be used partly as the latter, it is most economical to have the feed water analysed, and the character and amount of chemical reagents determined to effect the necessary purification. These reagents, of definite strength and known amount properly proportioned for the conditions, should be pumped in with the feed water as it passes into the boiler.

*(To be continued.)*

# New Companies Registered.

RANSOME AND MARLES BEARING CO. LTD. (145,799).—Registered January 17th. Capital, £60,000, £1 shares. To take over the ball and roller bearing branch of the business of A. Ransome and Co. Ltd., and to carry on the business of engineers, manufacturers of agricultural and other machinery, etc. Minimum cash subscribed, seven shares. Directors: V. S. Woods, Mayfield, Retford; L. H. Ransome, Farndon, Newark-on-Trent; and J. C. Clark, Goldstone House, Hove. Qualification, £100. Registered office: Stanley Works, Newark-on-Trent.

BRITISH REFRIGERATING CO. LTD. (145,776).—Private company. Registered January 16th. Capital, £100,000, 98,000 ordinary shares of £1 each and 40,000 deferred shares of 1s. each. Manufacturers of refrigerating and other machinery, etc. Agreement with the Auto-vacuum Refrigerating Co. Ltd. Directors to be appointed by the subscribers. Solicitors: Surtees, Phillpotts, and Co., 6, St. Helens Place, E.C.

BROWNLIE AND GREEN LTD. (145,806).—Private company. Registered January 18th. Capital, £30,000, £1 shares (10,000 preferred). Engineers, electricians, etc. Directors to be appointed by the subscribers. Registered office: 2, Austin Friars, E.C.

UNITED AIRCRAFT CO. LTD. (145,802).—Private company. Registered January 17th. Capital, £5,000, £1 shares (4,000 7 per cent preferred). Manufacturers and designers of and dealers in aeroplanes, automobiles, etc. Agreement with F. J. Osborn and L. S. Forbes. Solicitors: R. C. Leach and Co., 19, St. Helens Place, E.C.

BRITISH SWITCHGEAR LTD. (145,852).—Private company. Registered January 25th. Capital, £40,800, £1 shares (40,000 preferred). Manufacturers of and dealers in electrical switchgear, etc. Agreement with Brook, Hirst, and Co. Ltd., Electric Control Ltd., and Erskine, Heap, and Co. Ltd. Directors: J. A. Hirst, J. M. Scott-Marshall, A. Erskine, and H. C. Siddeley. Qualification, one ordinary share. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

PARSONS AND DICKINSON LTD. (145,863).—Private company. Registered January 26th. Capital, £1,000, £1 shares. Mechanical and general engineers, founders, etc. Directors: S. G. Dickinson, B. Parsons, C. Dickinson, and C. Rainbow. Qualification, five shares. Registered office: 1, High Town, Luton, Beds.

ALLOY FOR BRASS FITTINGS.—A mixture which a writer in *The Brass World* recommends for brass fittings which have to be machined is: Copper, 85 per cent; tin, 5 per cent; lead, 5 per cent; zinc, 5 per cent. This is said to cast well and machine freely.

EXTENSION OF BOILER PATENT. In the Scottish Court of Sessions the petition by the Inglis Boiler Syndicate Ltd., Glasgow, for the extension of the life of the Patent No. 5939 of 1903, granted to Mr. Inglis "for improvements in and relating to fire-tube steam boilers of the marine or like type," was recently heard, and it was decided that the patent be prolonged by seven years.

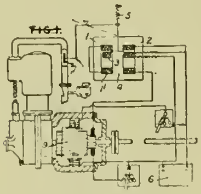
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

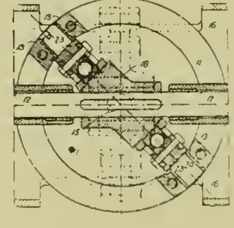
## ABSTRACTS OF SPECIFICATIONS.

### ELECTRO-MECHANICAL POWER TRANSMISSION.

102,501.—SOC. AUXILIAIRE DES TRAMWAYS ET CHEMINS DE FER (SOC. ANON.), 23, Rue de la Regence, Brussels.—Nov. 28th, 1916, No. 17,072. Convention date, No 29th, 1915. Not yet accepted. Abridged as open to inspection under Section 91 of the Act. Relates to a mixed drive for vehicles in which a dynamo-electric machine 9 and a battery 6 are associated with an internal-combustion engine, the machine 9 being driven as a motor from the battery to assist the engine on up grades and at starting, and acting as a generator to charge the battery along the level and on down grades. The invention consists in the provision of special electro-magnetic devices which vary the supply of fuel to the engine during charging of the battery and which keep the inlet valve of the engine wide open for maximum power during the periods when the battery is discharging. The electro-magnetic devices are provided with coils energised in accordance with the current and voltage of the battery, and one of the coils (preferably the voltage coil) is mounted so that it may move in oppositon to a spring, etc. In one arrangement, the current coil is divided into two parts 1, 1' mounted on a central core 4 within an iron cylinder 2, and the movable voltage coil 3 is connected mechanically to the inlet valve 7 of the engine; the coil 3 is adapted to act as an air dash-pot in the cylinder 4, and its position is controlled by a spring 5. In a modification, the coils are not provided with iron cores, and the voltage coil is mounted on a pivoted lever and is either attracted or repelled by the current coil, according as the battery is discharging or being charged. In a further modification, the voltage and current coils are arranged as in a dynamometer. Instead of direct actuation of the engine valve, the movements of the coil may be used to vary resistance in the circuit of an electro-magnet which adjusts the valve.



Patent 102,501



Patent 102,514.

### VARIABLE-SPEED GEARING.

102,514.—W. HUNT, 28, Bute Gardens, Hillhead, Glasgow.—January 7th, 1916, No. 273.—Relates to variable-speed gears of the type described in Specification 21,414/12 in which the gear varies automatically with the load. In the present application, the oscillating inertia members are so connected to both driving and driven members that their phases of acceleration and retardation are approximately equal. The driving or driven shaft 12 carries a swash-plate 18 carrying on ball bearings a gimbal ring 23, which has pivots 24 engaging blocks 13 secured by bolts 14 to two flywheels 11 arranged one on each side of the shaft and having pivots 15 engaging a driven or driving casing 16. Unless the parts 12, 16 rotate at the same speed, the swash-plate 18 produces oscillation of the flywheels 11, the amount of oscillation varying with the difference in speed of the primary parts, and this difference depending on the load. Cams or Z-cranks may replace the swash-plates. In a modified form, the flywheels are dispensed with, the gimbal-ring 23 being heavily weighted and pivoted in a second ring replacing the flywheels and pivoted on the casing 16 at the points 15. When used for driving purposes three such devices are arranged in a single casing with the swash-plates arranged at an angle of 60 deg. or 120 deg. to each other; or, in the form in which the flywheels are used, the swash-plates may be arranged parallel, and the flywheels be arranged at the required angles. In the Provisional Specification, references are made to the use of cross-slide or straight-line-motion devices for connecting the inertia members to the primary parts, and to the arrangement of the inertia members so that their axes are parallel to the main axis or so that they reciprocate in an axial or radial direction.

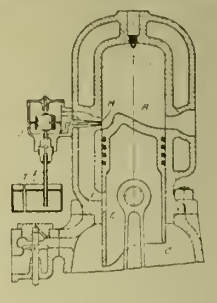
### PUMPS.

102,516. W. G. HEPPEL, "Hesperus," Clarence Road, Southsea.—January 8th, 1916, No. 366.—In pumps of the Williams-Janney and Hele-Shaw types, the tilting box A1 or eccentric ring controlling the stroke is automatically adjusted by a pressure governor comprising a piston B exposed on one side to the delivery pressure of the pump, and on the other side to a resistance such as a spring B2.

### INTERNAL-COMBUSTION ENGINES.

102,517.—SIR K. I. CROSSLEY, Openshaw, and J. HUTTON, Moorside, Burnage Lane, Burnage, both in Manchester.—January 11th, 1916, No. 430. In two-stroke cycle engines of the type in which fuel is injected through an air port H uncovered by the piston at the end of the outstroke, the float chamber J from which the fuel flows is charged from a tank T beneath it by opening communication between the chamber J and the crank chamber

Patent 102,516.

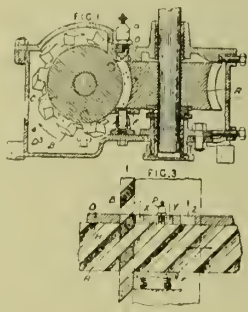


Patent 102,517.

C when a partial vacuum exists in the latter and the port H is closed to the combustion chamber A by the piston. This occurs when the ports E, F register at the beginning, or the ports E, H at the end, of the up-stroke.

### ROTARY ENGINES.

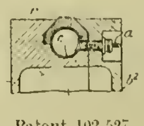
102,520.—J. M. SANDERS, Lichfield Lodge, Keynsham, near Bristol.—January 17th, 1916, No. 700.—A rotary internal-combustion engine of the type in which a grooved worm-wheel is engaged by a toothed wheel, comprises a rotor A having peripheral inclined grooves H which co-operate with the teeth B of a rotary abutment C forming working chambers confined above by a casing-plate D, below by a spring-pressed plate F, and at the periphery by an axial extension of the rotor C. As the rotors rotate, each groove H receives a compressed charge through an inlet X in the plate D and passes successively a



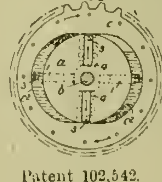
sparking-plug P, a water inlet Y for injecting cooling-water, and an outlet Z for the exhaust gases. The rotors A, C may be of different diameters and rotate at different speeds; more than one rotor C may be arranged to gear with the same rotor A, and the positions of the ports in the plate D may be varied. The rotors run in oil in the box D3. To maintain the same clearance between the teeth and the grooves as the parts heat up, metals having different coefficients of expansion may be used for the different parts. The Provisional Specification describes a different exhaust arrangement, the exhaust gas following the tooth out of the groove.

### PISTONS.

102,527.—S. DREYFUS, Thorncliffe Villa, Windmill Lane, Denton, near Manchester.—January 26th, 1916, No. 1,216.—Piston packing, particularly applicable for nitric-acid vacuum pumps, consists of a ring of indiarubber or similar material expanded by one or more inflated indiarubber tubes, which may be separate from, or formed in one with, the packing-ring. The figure shows a piston built up of one or more plates *b*1, *b*2, between which are secured one or more indiarubber rings *a* expanded by indiarubber tubes *c* inflated through valves *d*. The parts *b*1, *b*2 are preferably undercut, the ring *a* being correspondingly shaped.



Patent 102,527.



Patent 102,542.

### CLUTCHES.

102,542.—F. H. MINGAY, Berfield, Bridge of Weir, Renfrewshire.—July 22nd, 1916, No. 2,222.—In centrifugally-acting segment friction clutches, the driving-shaft *b* carries a disc *a* in which slide heavy plates 1, which may slide on antifriction rollers 4 and may carry in their ends rollers 3 adapted to bear against the inner surface *c*2, somewhat elliptical in form, of a driven casing *c*. The chamber may be closed by a cover and contain oil, which is confined within the converging walls of the oil-chamber and assists the drive.

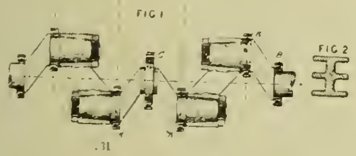
## VALVES.

102,550.—J. SHANKS, Tubal Works, Barrhead, and W. GALLAGHER, 7, Robertson Street, Greenock, both in Renfrewshire.—March 4th, 1916, No. 3,285.—In a valve device for the discharge from ships' closets, such as is described in Specification 16,049/15 and having a screw-down stop valve 1 and a non-return valve 2

in superposed relationship, the screw-down valve is arranged to be operated by a member which is rotatable but immovable endways. This may be an internally screwed sleeve 6 mounted, as shown, to rotate but not reciprocate, and to engage the screwed valve stem 5; or it may be an externally screwed spindle similarly mounted.

## CRANKSHAFTS.

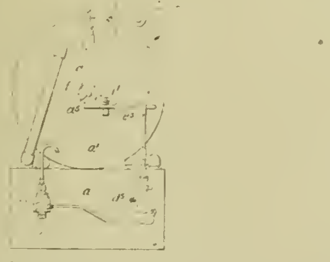
102,555.—G. ST. B. S. WATKINS, Coombe Place, Lewes, and G. FUNCK, Violette, Quinton Road, Coventry.—March 22nd, 1916, No. 4,234.—A crankshaft for multicylinder fluid-pressure engines is provided with narrow ball or roller bearings for the shaft and



crank-pins, and wide angular webs; it is of the built-up type and preferably has webs of channel section. The built-up shaft shown has roller bearings A, B, C with the surfaces of the outer race rings spherical, roller bearings K, and webs of the section shown in the fig.

## AIR GAS.

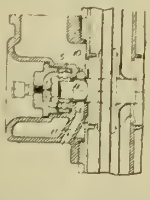
102,576.—W. C. SHARPE and W. C. SHARPE, Clacton House, Heath Park Road, Romford, Essex.—May 24th, 1916, No. 7,387.—An air-gas plant comprises a weight-driven rotary blower $a1$ and a gas-holder both mounted on a carburettor $a$, and a reciprocating



petrol pump $d5$ driven by a lever $e3$ actuated by a ratchet-wheel $f$ on the blower shaft $a5$, an adjustable stop $f1$ being provided for varying the stroke of the pump. A float valve $e1$ is interposed between the petrol reservoir and the pump $d5$. Rise of the gas-holder is arranged to close a valve $c1$ in the inlet of the blower $a1$.

## CENTRIFUGAL PUMPS, ETC.

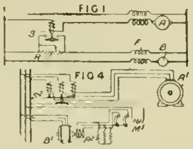
102,578.—G. DOD, Curzons Road, Southport, Lancashire, and IMPERIA CO., Derby Street, Cheetham Hill Road, Manchester.—May 26th, 1916, No. 7,486.—In a single or multi-stage centrifugal



pump, access of dusty air to the bearings 5 at one end or both ends of the impeller-shaft 4 is prevented by providing around the shaft between the bearings and the impeller casing, a chamber 10 communicating with the atmosphere by a conduit 11.

## ELECTRIC MOTOR CONTROL.

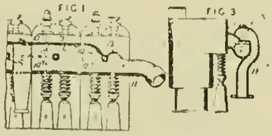
102,585.—IGRANIC ELECTRIC CO., 147, Queen Victoria Street, London.—(Cutler-Hammer Manufacturing Co., Milwaukee, Wisconsin, U.S.A.)—June 30th, 1916, No. 9,249.—Means responsive to the load on a working motor are employed to control a feed-motor to regulate the supply of work to the main motor. The winding of the vibrating relay S is connected in series with the working motor A, and the relay when lifted, short-circuits a resistance R in the shunt field circuit of the feed-motor B. If the load on the working motor A increases above a predetermined limit, the relay responds, and the field of the motor B is strengthened; the feed of work to the motor A is therefore



diminished. In a modification, an additional vibrating relay is connected to short-circuit the resistance R upon the occurrence of an excess current in the motor B. In another modification, the resistance is connected in the armature circuit of the motor B and is short-circuited by an electro-magnetic switch as long as the relay S is not operated by an excess current. The arrangement may be applied to alternating-current motors. The windings of the relay S2, Fig. 4, are connected in the stator circuit of the working motor A. The resistance R2 in the rotor circuit of the feed-motor B1 is normally short-circuited by an electro-magnetic switch M1. This switch is released to insert the resistance R2 when the relay S2 is lifted.

## INTERNAL-COMBUSTION ENGINES.

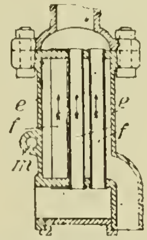
102,584.—M. L. WILLIAMS, 5,413, Woodlawn Avenue, Chicago, U.S.A.—June 17th, 1916, No. 8,590.—The admission pipe 10 and



exhaust pipe 11 are cast together and divided by a partition 12. The branches 14, 13 leading to and from the cylinders are close together and on the same level.

## INTERNAL-COMBUSTION ENGINES.

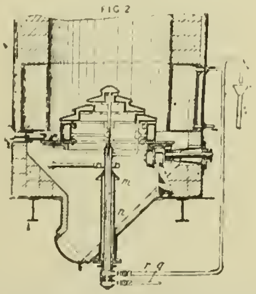
102,592.—E. RUSSELL, 45, Kedleston Road, Derby.—Aug. 19th, 1916, No. 11,772.—Mixture from a spray carburettor passes upwards through the tubes $f$ of the vaporiser around which the exhaust passes. Oil on its way to the carburettor is heated in a passage



$m$ in the wall $e$ of the vaporiser, which is also provided with a door. A modified form of vaporiser for bicycle engines is described also. Gauze discs may cover one or both ends of the pipes $f$.

## GAS PRODUCERS.

102,597.—F. THUMAN, 38, Victoria Street, Westminster.—Sept. 16th, 1916, No. 13,178.—The water-cooled rotary grate of a gas-producer is connected to axially-arranged flow and return tubes $m$, $n$

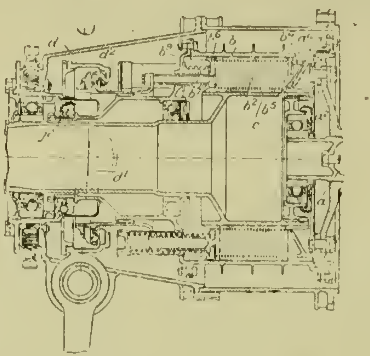


which pass through stuffing-box connections in the hopper-shaped ash-pit and are connected to inlet and outlet mains $q$, $r$. They are protected from hot ashes by a tubular extension of the stuffing-box.

## CLUTCHES.

102,700.—F. H. ROYCE, Nightingale Road, Osmaston Road, B. I. DAY, 49, Harrington Street, and ROLLS ROYCE LTD., Nightingale Road, Osmaston, all in Derby.—July 28th, 1916, No. 10,707.—In multiple-plate and other friction clutches, means are provided for preventing end thrust on the shafts. The clutch casing $b$ is con-

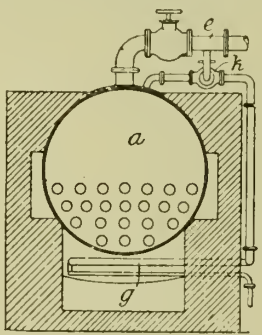
nected by serrations $a4$ to a flange $a2$ secured to the driving shaft $a$, a sleeve $b9$ bolted to the casing bearing against the framing through a thrust bearing $j2$. Springs $b7$ seated in the part $b9$ bear against the presser-plate $b6$ and compress the plates $b2$ against a ring $b4$ abutting against projections $b5$ in the casing $b$, thus preventing external end thrust. The operating lever $d1$



engages a collar $d$ bearing on a sleeve $d2$ secured to the presser-plate $b6$. During disengagement of the clutch the springs $b7$ are compressed and the casing $b$ moves slightly on the serrations $a4$ so that the end thrust is taken up by the bearing $j2$, and at no time is there end thrust on either the shaft $a$ or the driven shaft $c$

**SUPERHEATING STEAM.**

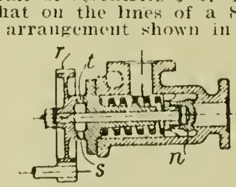
102,678.—H. BROWN, The Red House, Parkside, Wimbledon Common, Surrey.—May 4th, 1916, No. 6,389. Steam is superheated by introducing into the boiler steam-pipe highly superheated steam from another boiler. An instantaneous generator $g$ in the flue

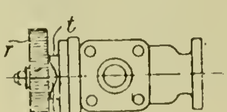



of a multitubular boiler $a$ supplies superheated steam to the boiler steam-pipe $e$ through a three-way cock $k$. When the steam-pipe $e$ is closed, the steam from the generator is passed into the boiler steam-space.

**INTERNAL-COMBUSTION ENGINES.**

102,762.—W. D. McLAREN and G. M. WELSH, 124, St. Vincent Street, Glasgow.—Feb. 14th, 1916. No. 2,151.—Reversible engines are started in either direction by steam or compressed air admitted either to a working cylinder or to the cylinder of a scavenging-air pump. The liquid-fuel supply for normal working, and the starting-fluid valves are actuated by linkage gear having rods $c$, $d$ actuated by a pair of eccentrics $b$ $c$. The linkage gear may be arranged somewhat on the lines of a Stephenson, Gooch, or Allan gear. In the arrangement shown in Figs 7$a$ and 7$b$, bell-




cranks J, W which actuate a fuel pump and a starting-fluid valve respectively, are engaged by the top sides directly, or by cam-surfaces on the top sides, of links $g$, $f$ In linking-up, the rods $x$ only are adjusted. A wedge (not shown) is inserted between the fuel-pump plunger and its actuating bell-crank to vary the stroke of the pump. The supply of compressed air to the starting-valves may be controlled by a valve (not shown) opened by a reversing-quadrant as it moves from its mid-position. According to a modification, Fig. 6, a controlling-valve $n$ is opened periodically by a wheel $r$ carrying cams $s$ which bear upon a stationary undulation $t$. The wheel moves axially with the valve stem.

# INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

VOL. V.] MARCH 22ND, 1917. [NO. 131.

## The Industrial Engineer.

*ENTIRELY DEVOTED TO POWER ENGINEERING.*

Published twice monthly, on the 8th and 22nd days, respectively.

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## CONTENTS.



# EDITORIAL.

## FEDERATION OF BRITISH INDUSTRIES.

IN spite of the pre-occupation of almost everyone in the War, there is an increasing tendency to give after-the-war problems plenty of attention. This is as it should be, for there is nothing better than taking time by the forelock and working at the problems gradually, if only to prevent panicky ideas arising, as they have the habit of doing when matters are rushed at the last minute. The Federation of British Industries is another case of timely and careful preparation. The first meeting was held in the Caxton Hall, Westminster, on the 2nd inst., with Mr. F. Dudley Docker, C.B., in the chair. It was stated that the Federation now reached a total of 269 firms and individuals and 50 associations, whilst 18 applicants were awaiting election. The Chairman referred, in the course of his speech, to the recent meetings which had been held between representatives of employers and of trade unions with a view to the distribution of labour after the war, and to dealing with any subsequent problem of unemployment or labour dislocation. He was glad to add that the representatives of the employers were members of the Federation. If the Federation, he proceeded, did nothing else but bring capital and labour together, it would be an achievement to be proud of. He ventured to think that the recent meetings in question had had a very good effect, and that the atmosphere of friendliness and co-operation which they had engendered would make subsequent negotiations with labour more easy and more productive. It would be necessary to speak plainly to labour in future, not to be afraid to ask what was wanted, and not to be afraid to give what ought to be given for fear of something more being demanded. The welfare of the Empire was essentially dependent upon the existence of a satisfactory understanding between employers and employed, and he hoped the Federation would play an important part in promoting such an understanding. These are wise words, and the ideas they express are worthy of wide acceptance.

## GERMAN INVENTIVENESS.

IN the course of an interesting paper on this subject before the Royal Society of Arts, by Mr. J. H. Vickery, LL.B., on the 7th inst., reference was made to the character of German inventiveness. A great many people in this country are of opinion that the German race excel in this direction, but we think if they were put to it they would have some difficulty in pointing to more than a very few lines in which the Germans excel either ourselves or our French and American friends. We are of opinion that German inventiveness is often mistakenly compared with German commercial push, a totally different matter. In general, the Germans are not an inventive race, with the sole exception of concocting war news, and they do this so clumsily as to support the contention that they are not clever at inventing. We see that in the discussion on the paper referred to Mr. James Swinburne, F.R.S., who is one of our most highly trained and versatile engineers, asserted that practically the only inventions "which came from Germany were in organic chemistry. Their method of working almost precluded them from inventing anything. In the early 'eighties, for instance, America was very active in developing electrical plant and machinery; England was equally active, but was hindered by legislation from doing much in the way of manufacturing. When he (Mr. Swinburne) went over a particular works in Germany, about the year 1890, he found that they had simply taken English and American practices and combined them, selecting the best of each, and in that way they had developed a huge business." We may add that this generally coincides with the opinions of many others who have been in a position to examine German methods.

# VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.

(*Continued from page 208.*)

## Epicyclic Gear.

After the sliding type of shaft-to-shaft gear, the epicyclic gear has found most favour, and while this type of change-speed gearing has been successfully employed in some motor road vehicles for many years, its application can only be considered as limited when compared with the sliding type of gear. While popular prejudice, which is always in favour of the thing which is known and understood, may account for its lack of adoption, it cannot be overlooked that, as compared with the sliding type of gear, its cost of manufacture by reason of the necessity for a high standard of workmanship is high, the number of its parts is comparatively large, it is difficult to obtain a useful ratio of speeds when three forward speeds are required without complication, and it calls for adjustment at intervals. Against these drawbacks it has several advantages over the sliding type of gear. For instance, it is practically silent on all speeds, it is less liable to break down or to be damaged through careless handling, and it is not subject to as much wear and tear. It will be seen, therefore, that while the disadvantages are nearly all matters for the manufacturer, the advantages are all on the side of the user. The best known gear of this type giving three forward speeds and a reverse is the Lanchester—Fig. 12—which has been used continuously and to the exclusion of all other types of gear in the Lanchester cars since 1900.

The Ford car may also be cited as an automobile in which the epicyclic type of change-speed gear is exclusively used, and in this case the increased cost of production of this type of gear certainly has not been a bar to its use, as the total cost of production of this car is known to be well below that of any other car of similar power and capacity, while its selling price has become a by-word. It must, however, be borne in mind that the gear fitted to the Ford car only provides two forward speeds.

Nothing is more fascinating than the possibility of effecting a smooth and gradual change of speed over the whole desired range, whereby the prime mover can always be kept running at its most effective speed. The exceedingly flexible petrol internal-combustion engine of to-day has eliminated much of the need that once existed for a gradual and infinitely variable change-speed gear, but the advantages of such a mechanism seem so apparent that much ingenuity has been exercised in the attainment of it.

## Variable-Speed Mechanisms.

The various mechanisms for obtaining a gradual and infinite variable speed may be classified as follows:—

(1) A mechanical system in which expanding pulleys and belts are used,

(2) A mechanical system in which the drive is by fractional contact,

(3) A mechanical system in which the drive is on the feed-gear principle,

(4) An hydraulic system, and

(5) An electric system in which current generated by a dynamo driven by an engine is employed, either wholly or partially, as the transmitting medium between the engine and the road wheels.

## Belt Gearing.

Belt gearing is now only used on light cars of the so-called cycle type, and expanding pulleys are successfully employed to vary the speed ratio. These are almost invariably of the double-cone type, so that the belt used with them has the shape of an inverted truncated cone, which gives the belt a better grip on the pulleys. In some cases two such pulleys are employed, so coupled together that as one is expanded the other is contracted, while in other cases one expanding pulley is employed, the slack being taken by a spring-controlled jockey pulley. In all these systems belts are employed, as an expanding pulley capable of running with a chain is not yet a commercial proposition.

## Friction Gearing.

A common form of frictional drive mechanism—Fig. 17—consists of two friction discs arranged at right angles to one another, so that the periphery of one engages the face of the other, the relative positions of the axis of one and the path of rotation of the other being capable of being varied. An interesting modification of this type of gearing is the Cowey—Figs. 18 and 19—in which the driving and driven discs engage one another face to face.

## Feed-Motion Gearing.

The most common form of variable-speed gear working on the feed-gear principle is one in which reciprocating pawls operate ratchet wheels, provision being made whereby the angle through which the pawls travel can be varied. This type of gear has not obtained any hold in automobile construction, due probably to the large number of working parts and the high speed at which the reciprocating parts must work if the size of the gear is to be kept within reasonable limits. The great defect, however, of this type of gear is that when the engine speed is slow, and especially when the torque is heavy, the driving motion is apt to become jerky. Several gears, for instance the Newman and the Barber, have passed through the experimental stage with apparent success, but the fact remains that they have not been successfully used commercially.

### LANCHESTER GEAR.

In this gear, Fig. 12, there are three epicyclic trains, the sun-wheel, planet wheels, and annulus of which are denoted by A, B, and C; D, E, and F, and G, H, and J, respectively, the first train giving the first or lowest speed, the second—in combination with the first—the second speed, and the third the reverse. The third or highest speed is obtained by locking the gears together by the action of a clutch, which, as shown, is of the multi-plate type. The essential feature of this gear is the compounding of two trains to produce the second or intermediate speed, the interaction being obtained from the driven element. The sun-wheels A and G of the first and third trains respectively are fixed on the driving shaft V, which is a continuation of the crankshaft of the engine. The driving shaft also carries the inner or male parts of the friction clutch, the female or outer parts of the said clutch being carried by a casing U, which is in permanent couple with the driven shaft W. Coupled with the casing U is a sleeve K, which is loosely mounted on the driving shaft V and carries a carrier L for the planet pinions B of the first train, this carrier, therefore, being in permanent direct couple with the driven shaft. The annulus C of this train is carried by a sleeve N, which is loosely mounted on the sleeve K and carries a brake-drum M. The sun-wheel D of the second train is fixed on the boss of a disk O, which is loosely mounted on the sleeve N and carries a brake-drum P. The planet-wheels E of the second train are carried by a carrier Q, which is fixed to the sleeve N, and therefore in permanent direct couple

with the annulus C of the first train. The annulus F of the second train is carried by a disk T, which is fixed on the sleeve K, and is therefore in permanent direct couple both with the carrier L of the first train and also with the driven shaft through the casing U of the clutch, the couple between the sleeve K and the casing U being by means of a dog-key carried by the boss of the disk T and engaging a recess in the boss

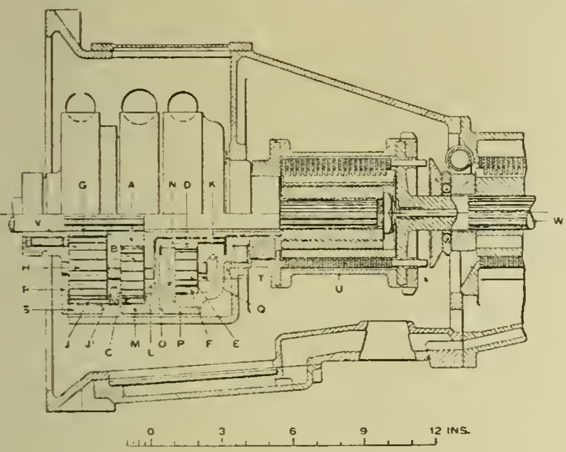


Fig. 12.—Lanchester Gear.

of the inner flange of the casing U. The planet-wheels H of the third train are carried by a carrier R, which is loosely mounted on the driving shaft V and carries a brake-drum S, and the annulus J of this train is mounted on a disk J[1], which is fixed to the carrier L of the first train, and is therefore in permanent direct couple with the driven shaft. It will be seen that the sun-wheel A, the sun-wheel G, and the inner or male part of the clutch are all coupled to the driving shaft, and therefore revolve at the same speed. Also that the outer or female part of the clutch and the sleeve K, and therefore the pinion carrier L, are coupled to the driven shaft.

To obtain the lowest speed, the drum M is held stationary, and as the sun-wheel A is driven by the engine the carrier L, and with it the pinions B, are caused to rotate as a whole in the same direction as the sun-wheel, but at a lower speed. This

Fig. 13.

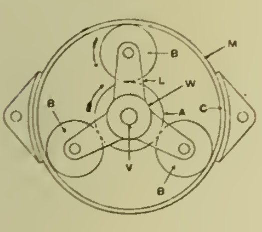


Fig. 14.

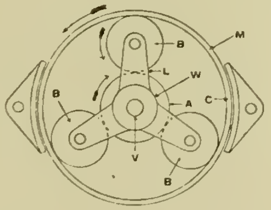


Fig. 15.

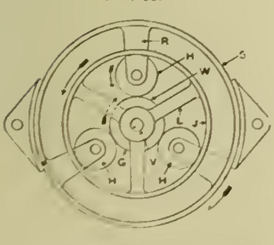
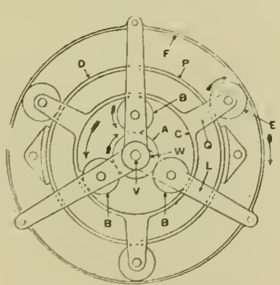


Fig. 16.



Figs. 13 to 16. Diagrams of Lanchester Gear.

is the ordinary form of epicyclic gear, and is shown diagrammatically in Figs. 13 and 14, the former showing the gear in action and the latter running idle.

To obtain the second speed both the train A, B, and C and the train D, E, and F are employed. The combined action of these two trains can best be followed by bearing in mind that the end to be attained is a speed intermediate between the highest speed, which is obtained by locking all the elements of the epicyclic trains together by means of the clutch, and the lowest speed, which is obtained as before described. This is effected by causing the carrier L of the first train to move faster, which end is attained by causing the pinion carrier Q of the second train, which is coupled to the annulus C of the first train, to revolve in the same direction as the carrier L by holding the sun-wheel D of the second train stationary by means of the drum P. This causes the carrier Q, and with it the annulus C, to rotate in the same direction as the sun-wheel A, which thus augments the speed imparted to the carrier L, and therefore the speed imparted to the driven shaft. The action of this compound gear is shown diagrammatically in Fig. 16, the elements D and F being enlarged to allow them to be shown concentric with but clear of the elements A, B, and C.

To obtain the highest speed—a direct drive—the clutch is brought into action which locks all the parts of the gear together, so that they revolve *en masse*. At all the other speeds the clutch is out of action.

To obtain the reverse, the drum S to which the planet carrier R is fixed is held stationary, so that the annulus J, and with it the carrier L, and therefore the driven shaft, will be rotated in a reverse and opposite direction to the driving shaft by the action of the intermediate pinions H. The action of this gear is shown diagrapmatically in Fig. 15.

## COMMON FORM OF FRICTION GEAR.

In this gear, Fig. 17, the driving disk A is counted on a shaft V, which is in couple with the crankshaft of the engine, and the driven disk B is mounted on a shaft W, which is

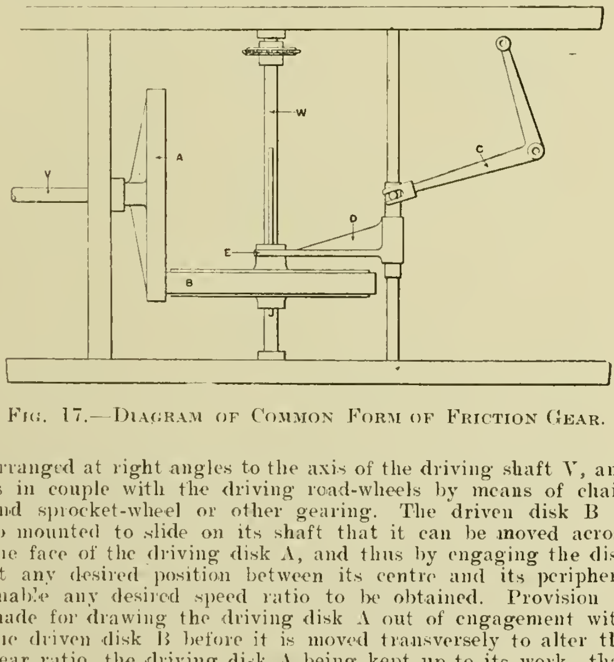


Fig. 17.—Diagram of Common Form of Friction Gear.

arranged at right angles to the axis of the driving shaft V, and is in couple with the driving road-wheels by means of chain and sprocket-wheel or other gearing. The driven disk B is so mounted to slide on its shaft that it can be moved across the face of the driving disk A, and thus by engaging the disk at any desired position between its centre and its periphery enable any desired speed ratio to be obtained. Provision is made for drawing the driving disk A out of engagement with the driven disk B before it is moved transversely to alter the gear ratio, the driving disk A being kept up to its work—that is, in frictional driving contact with the disk B by means of suitably-arranged spring-pressure.

The reverse is obtained by bringing the driven disk B over to the other side of the driving disk A, and it is usual in this form of gear to recess the driving disk in the centre so as to provide a neutral point in which motion is not imparted to the driven disk. The driving contact between the two disks is broken by drawing the driving disk A back out of engagement with the driven disk B, which is usually effected by means of a foot-pedal operating similarly to a clutch-pedal, and the position of the one disk in relation to the other is varied and determined by means of a hand-lever working over a notched bar or quadrant and in couple with the sliding driven disk B through the bell-crank lever C and a sliding element D, which carries a fork E that engages a groove in the boss of the sliding disk.

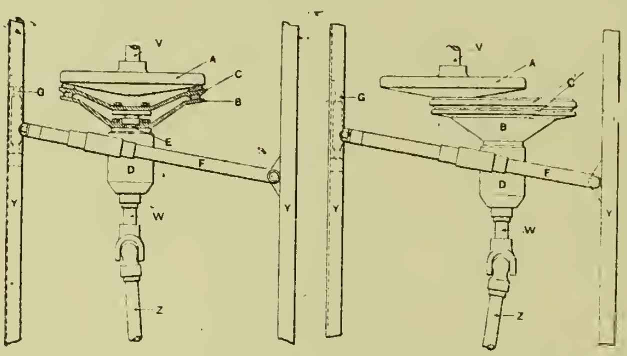
## COWEY FRICTION GEAR.

In this gear, Figs. 18 and 19, the driving and the driven disks engage one another face to face. The former shows the

disposition of the parts when the engine is driving the transmission shaft at its highest speed, and the latter the disposition of the parts when the engine is driving the transmission shaft at a reduced speed. Between the rear face of the disk A mounted on the crankshaft V of the engine and a disk B mounted on the driven shaft W is an intermediate disk C. The rear face of the disk A is coned, and both the disk B and the intermediate disk C are dish-shaped, the former being faced on one side and the latter on both sides with a suitable friction material such as "Feredo." The disk B is carried by the driven shaft W, the front part of which is mounted in bearings in a housing D and is hollow to receive the shaft E which carries the intermediate disk C. The rear end of the driven shaft W is coupled to the propeller-shaft Z by the usual universal coupling. The housing D is mounted to slide on a frame F (which consists of a pair of transversely-arranged superimposed bars), which is pivoted at one end to one of the side members Y of the frame of the chassis and is adapted at the other end to slide in or on a suitable guide G carried by the other member Y of the frame. Means are provided both for operating the frame F for the purpose of pulling the driven disk B out of engagement with the intermediate disk C so as to disengage the driving couple, and to move the housing D carrying the driven and intermediate disks and their shafts laterally in relation to the disk A so as to cause the intermediate disk C to engage the face of said disk at a different part of its surface.

It will be seen that when the axes of the driving shaft and of the driven shaft, and therefore of the disk A and the intermediate and driven disks C and B are co-axial, the apparatus is simply a direct-driving clutch, and that to obtain the lower speeds and the reverse it is only necessary to move the disks B and C across the face of the disk A so that the rim of the intermediate disk C will engage with a portion of the surface of the driving disk which is nearer to its centre, and obviously the nearer the driven disk is moved towards the centre of the driving disk the greater is the effective speed reduction. If the rim of the intermediate disc C is moved beyond the centre of the driving disk the direction of rotation of the driven shaft is changed, which gives the reverse drive. The housing D carrying the intermediate and driven disks C and B is coupled to the clutch-pedal, so that it can be drawn backwards sufficiently to disconnect the engine from the disks by depressing the pedal, a suitable spring being employed to return the housing and keep the disks up to their work when pressure on the clutch-pedal is removed. Within the housing D at the rear end of the shaft E carrying the intermediate disk C is a helical spring, which operates between the end of the shaft and the end of the hollow part of the driven shaft W. This spring, when the housing D is drawn back, separates the intermediate disk C from the driven disk, so that when the clutch pedal is depressed not only is the intermediate disk separated from the driving disk but also from the driven disk, so that there is no rubbing friction whatever between these parts. The effect of the use of the intermediate disk is to provide a complete annular clutch which renders wear a negligible quantity. In this gear all the drives are direct, so that loss in transmission is reduced to a minimum and at all speeds is silent. Further, as any gear and the reverse can be easily and rapidly engaged at any engine or car speed a valuable emergency brake is provided.

*(To be continued.)*




Figs. 18 and 19.—Diagrams of Cowey Friction Gear.

## STORAGE BATTERIES.

By F. Ashton.

*(Continued from page 215.)*

### Low Specific Gravity.

Low specific gravity may be attributable to insufficient charging or insufficient work. The specific gravity, and to some extent the voltage, are also, as already indicated, dependent to some extent upon the temperature, and in taking specific gravity readings the temperature ought, in the absence of a compensating hydrometer, to be taken into account. Roughly speaking, an increase of one degree in the specific gravity ought to be allowed for each three degrees decrease in temperature below 60 deg. Fah. and *vice versa*. If, however, it is found at the end of an overcharge that with a normal temperature of 60 deg. Fah., the specific gravity is appreciably lower than it ought to be something is obviously wrong. More acid may or may not be required. Generally speaking, accumulator manufacturers like to be consulted before acid is added, in order that they may ascertain whether the low specific gravity is attributable to natural effects or to high temperature, or other causes. Low specic gravity, it is to be remembered, may be brought about in individual cells by internal short circuits, by impure water, insufficient charging, insufficient work as well as by high temperatures, and to add acid under such conditions is worse than useless. Similarly, if a low specific gravity is attributable to abnormal temperature, short circuits, etc., it is obviously useless to try and remedy matters by charging.

### Charge and Discharge Rates.

Strict attention ought to be paid to the maximum charge and discharge rates specified by the makers. A normal rate of charging is specified, and should be adhered to if possible, but if a higher rate of charge is essential the maximum permissible as given on the instruction sheet should on no account be exceeded. The capacity of a cell or the amount of electricity it can give on discharge is measured in ampere hours. A cell that can supply 25 amperes for eight hours before the lower limit of the limit of the electromotive force (which is usually about 1·8 volts per cell) is reached, is said to have a capacity of $25 \times 8 = 200$ ampere hours. Experience shows that the capacity of a cell depends essentially upon the rate of discharge, and the more rapid this is the less is the capacity in ampere hours. The above cell, if discharged at the rate of 100 amperes, would be completely discharged in one hour; hence, in speaking of the capacity of storage batteries, it is necessary to mention the number of hours in which the battery is supposed to be discharged. If a battery is intended to be discharged in a shorter period than the normal its rated capacity must be reduced in a ratio stated by the manufacturer. One of the reasons for the decrease of capacity at the higher rates of discharge is that the acid cannot circulate as rapidly as required, the effect being that the acid in the plates is diluted before fresh acid can take its place. Another reason is that a layer of lead sulphate is formed on the surface of the plates, which prevents further action.

### A Guide to Condition.

As a guide to the condition of a battery, use is now often made of a single cell belonging to the battery, and once this cell has been selected it is adhered to unless, of course, it gets into a bad condition, and has to be specially treated Specific gravity and voltage readings taken on this cell

serve as a guide to the general state of the battery; although, of course, similar readings must be taken on the other cells from time to time. Great care is taken to keep the electrolyte in the observation cell at a fixed level. One large firm of accumulator makers recommends that the regular charges be continued until the specific gravity of the observation or pilot cell attains a value 5 deg. below the maximum reached on the preceding overcharge, and until the voltage across the battery attains a value corresponding to something between ·05 and ·1 volts per cell below the last overcharge voltage, due allowance being made for any difference of temperature. The weekly overcharge is simply an extension of one of the daily regular charges. It should always be given on the same day of the week, and should be continued until five specific gravity readings on the pilot cell taken at 15-minute intervals show that the specific gravity has attained a steady value. Similarly, five voltage readings taken across the terminals of the battery at 15-minute intervals should show with constant charging current a practically fixed pressure before the charge is stopped. It is to be noted, however, that the voltage across a battery will not necessarily always be the same at the end of every overcharge, for the voltage varies with the charging rate, the temperature of the electrolyte, and the age of the battery. Higher or lower charging rates give respectively higher or lower final charging voltages.

### Battery Pressure.

A fully-charged cell gives a pressure of a little over two volts on open circuit. If allowed to remain on open circuit the pressure will decrease slightly, but will not drop below two volts as long as it remains on open circuit. When on discharge the pressure begins to drop to slightly under two volts, it may remain at two volts for some time, depending on the rate of discharge. Apart from the fact that a complete discharge down to zero voltage would ruin the battery, complete discharges are impracticable for the reason that for all ordinary purposes the terminal voltage of a battery must be constant within rather narrow limits. Lead batteries should always be recharged when the minimum voltage specified by the makers is reached, for, as already explained, the lead sulphate which is formed during discharge is practically an insulator, and if too much of this material is allowed to accumulate on the plates the reduction back to lead peroxide is very difficult, if not impossible. Enough lead or lead peroxide must remain on the plates to keep down their resistance, otherwise the charging current cannot pass through the active material, and the regenerative action of the cells is lost. When a battery is being charged the voltage applied at the terminals must, of course, be high enough to overcome the counter electromotive force of the cells and to force the charging current through the ohmic resistance. At the end of a charge it is usually necessary to apply about 2·65 or 2·7 volts per cell, but this, of course, depends upon the age of the battery and other conditions previously mentioned.

### Adding Water.

Owing to the gassing which takes place when a battery is charged, and particularly when it is overcharged, a portion of the electrolyte is evaporated, and this must be compensated for by the addition of distilled water. Great care must be exercised to ensure that this water is free from impurities, and it is advisable when this water is not obtained from the makers to submit a sample to them in order that they may ascertain whether it is suitable for the purpose. Rain water is sometimes used, but it may, of course, contain impurities, and advice with respect to its suitability for batteries should be sought before it is put into the cells. Water that is obtained from steam pipes and other parts of steam plants is, as a rule, unsuitable for "topping up" purposes, owing to the impurities it contains. Impurities in the electrolyte and in the lead from which the plates are made, and in the sulphuric acid, produce local chemical actions which may quickly ruin the plates; hence the makers' restrictions with respect to purity are not to be wondered at. When "topping up" cells sufficient distilled water should be added to make the electrolyte rise about half-an-inch above the tops of the plates, and on no account should the plates in any of the cells be left uncovered. When a pilot or observation cell is used the electrolyte in this cell should always be kept at exactly the same level by adding a small quantity of water daily, the object being to prevent sudden changes in the specific gravity. If impurities find their way into cells the electrolyte should be removed and replaced with a fresh electrolyte when the battery is in a discharged condition, and after the cell has been flushed out with clean water.

*(Concluded.)*

## FEED WATER FOR STEAM BOILERS.

By Arthur C. Scott and Prof. J. R. Bailey.

*(Continued from page 217.)*

### Blowing-off Boilers.

The main factors in ordinary boiler-water purification are heat, soda ash, and blowing-off, with possible filtration when this can be arranged, as is sometimes done with the hot process. The blowing-off is important. It should be done under low pressure to be effective in carrying out the sludge and to reduce boiler stresses coincident with rapid blowing under high pressure. If it must be done under high pressure, the valves should only be "cracked"; otherwise only a small part of the sediment will be carried out, because the vortex or whirlpool formed draws down clear water, leaving the main body of the sludge intact. Undoubtedly some of the troubles recorded as due to scale-forming water are really attributable to the disregard of proper methods of blowing-off, and to the pumping in of cold water, thereby overstraining the boiler material.

### Kerosene for Scale Troubles.

The success of kerosene oil in removing and preventing scale is undoubtedly due to mechanical action alone. To be effective the oil should be put in after the boiler is emptied and washed, and the boiler should be refilled slowly from the bottom. It is useless to pump the kerosene in with the feed water, for it may tend to form a non-conducting film over the heating surfaces that will introduce an element of danger.

### Boiler Troubles Caused by Corrosion.

The trouble due to corrosion of sheets, tubes, stays, etc., is in some cases more acute than ever occurs with scale. Carbonic acid gas, occluded oxygen, and sodium and magnesium chlorides are the most frequent offenders, and the chlorides are so difficult to remove that the cost is practically prohibitive. Corrosion due to the chloride ingredients is particularly destructive to steel boiler tubes, hot-water piping, and brass-seated valves. Galvanised steel pipe is not immune, because any defect in the zinc coating permits local galvanic action, with consequent rapid de-

struction of the zinc coating. Water with as much as 500 parts to a million of these chlorides, especially when hot, is destructive to steel pipe and fittings.

Waters are frequently both scale-forming and corrosive; usually a water having a corrosive tendency will be more or less scale-forming. Caustic or carbonate alkalies or caustic lime act as neutralising agents for corrosive ingredients, but must be carefully handled or the scale-forming matter will be increased. Their use should be confined to treatment of the water outside the boiler if possible.

### Boiler Troubles Due to Foaming or Priming.

Boiler troubles due to foaming or priming apparently depend largely upon the concentration of alkali salts in the water, although silt, organic matter, loosened scale, lubricating oil, character of load, and design of boiler all have an appreciable bearing upon this phenomenon. Surface blowing is a remedy where it can be applied, and usually the proper use of the main blow-off will reduce the concentration of salts in the boiler. There are many natural waters of sufficient alkali content to produce immediate foaming whenever the pressure at the surface of the water in the boiler is relieved by the sudden and large use of steam. As there is no chemical treatment that will precipitate alkalies from solution, such waters are to be rejected for boiler use.

### Chemical Procedure in Water Softening.

Excepting waters containing hydrogen sulphide, all natural waters contain the same ingredients. The analytical chemist makes the same determinations in the same way on every sample of water which he investigates, unless the water contains hydrogen sulphide. He determines silica, iron oxide, and alumina, together with the following important basic and acid ions:

| Basis Ions (B). | Acid Ions (A). |
|---|---|
| Potassium and Sodium | Chlorine |
| Magnesium | Carbonic Acid |
| Calcium | Sulphuric acid |

Were it possible to make all the determinations without experimental error, the basic ions (B) would be found present in just the right amount to combine with the acid ions (A), forming "salts." Chemists universally regard the ions as the form in which salts exist in solution, but engineers are more accustomed to water analyses expressed in the form of salts. When so given the nature and amount of chemical treatment necessary for softening water are very clearly shown.

In the discussion of boiler waters it is well to divide the salts present into (1) the alkali salts, that is, the salts of potassium and sodium, and (2) the calcium and magnesium salts. The alkali salts do not crystallise out under the conditions attained in the boiler, and therefore cannot produce scale. Apart from the small amount of silica, oxide of iron, and alumina, the scale formed in boilers is due entirely to calcium and magnesium salts. These are commonly spoken of as constituting the hardness of water, and it is customary to divide hardness into two kinds—temporary and permanent.

### Hardness in Water and its Reduction.

The combined bicarbonates of magnesium and calcium constitute temporary hardness, while the other salts of magnesium and calcium constitute permanent hardness. Temporary hardness can always be expected in river, spring, and well waters, but a great many waters do not possess permanent hardness. Waters with less than 8 grains per gallon of scale-forming material are considered very good; 8 to 15 grains good; 15 to 20 fair; 20 to 30 poor; 30 to 40 bad; and over 40 very bad. Scale due principally to temporary hardness will deposit as a loose sludge, readily blown off. Where the ratio of permanent to temporary hardness exceeds 1 to 4, the scale will be hard, cement-like, and very adhesive to boiler metal.

Water treatment, or softening, removes the greater part of the calcium and magnesium. The bicarbonates are removed practically altogether, but of the sulphates and chlorides the calcium and magnesium are removed and the $SO_4$ and Cl left in the water. As an equilibrium must exist between the basic and acid ions, other basic ions must be substituted by adding soda ash.

When water is softened outside the boiler and the sludge removed by sedimentation and filtration before the water enters the feed-water heater, the chemicals used in the treatment are either lime alone or lime and soda ash. If the lime and magnesium are present as temporary hardness alone, that is, as bicarbonates with the sulphates of these bases absent, lime suffices for the chemical treatment. If either the magnesium or both the magnesium and calcium are present in other salts, the lime treatment must be supplemented by soda-ash treatment. No chemicals other than lime and soda ash are used under ordinary conditions in water softening. There are others that would do the work more efficiently, but their cost precludes their use.

### Chemical Control in Water Softening.

No matter what the patent features of a water-softening system may be, it is impossible to regulate automatically the feed of chemicals to compensate fluctuations in the scaling ingredients of the water. The best results can be obtained only by controlling with chemical tests the successive batches of water treated. They require the use of standard acid in connection with two indicators, phenolphthalein and methyl orange with the use of a standard soap solution.

### Corrosion and Foaming.

Pitting and corrosion in boilers are frequently due to magnesium chloride and less often to calcium chloride. Either of these salts is very pernicious, in that on hydrolysis it produces free hydrochloric acid. This action is, however, in large measure counteracted when the temporary hardness runs high. Waters high in nitrates are always highly corrosive. Large amounts of sodium chloride also tend to make waters corrosive. Some waters very low in mineral content produce corrosion, especially at the feed-water intake, owing to a large amount of dissolved oxygen and free carbonic acid. Peaty waters are harmful to boilers by reason of the vegetable acids they contain. Waters containing a free mineral acid are particularly harmful.

Waters which contain large amounts of alkali salts, especially sodium carbonate and sodium chloride, have a tendency to foam. Suspended matter of any kind increases the foaming tendency. Waters low in mineral content but high in organic matter, though perfectly clear, may also be troublesome. Sodium salts, in most cases sodium sulphate, are augmented in the softening process. Some waters are so high in initial alkali salts that they will not stand a further addition from the soda ash used as softener without producing serious foaming. In such cases barium hydroxide can be used as a substitute for soda ash, although it is expensive. All barium salts that are soluble are poisonous.

From what has been said relative to the effect of large amounts of alkali salts on waters, it is evident that one

good result to be obtained from chemical control in water softening is the prevention of an overfeed of soda ash, as any large excess of this chemical will produce a foaming water. The only methods of combating foaming waters appear to lie in frequent blowing off and washing out the boilers, and along lines of improved boiler construction.

*(Concluded.)*

## SAVING THE HEAT IN GAS-ENGINE COOLING WATER.

By T. B. Hyde.

There are a number of small power plants throughout the country in which both gas and steam engines are used, and still others where gas engines are used for power with steam required for other purposes. In Figs. 1 and 2 two methods are shown which have been used for making gas-engine cooling water available for boiler feed make-up without loss of heat to the system.

A gas engine requires for cooling purposes in the neighbourhood of 60 lbs. of water per hour per delivered horse power, depending upon the temperatures of injection and discharge. In order to keep down water bills it is customary to return this water to a cistern through cooling devices such as spray nozzles, cooling racks, and the like. Where steam boilers are operated in the same plant, the boiler feed make-up is often taken into the feed-water heater direct from the city or service mains or from the cistern.

The gas-engine cooling water is usually discharged from the engine at a temperature of 125 deg. to 135 deg. Fah., while its temperature in the cistern, after cooling, will be in the neighbourhood of 70 deg. to 85 deg. Water from city mains averages about 50 deg. Fah. Thus each pound of gas-engine discharge water used in the feed-water heater represents a saving of 60 B.Th.U. over cistern water and 80 B.Th.U. over city water. It should be remembered that each 10 deg. saved in this manner represents a saving of 1 per cent in the fuel required to heat and evaporate the quantity of water affected. A further and by no means insignificant advantage in some cases is that the cold make-up water for the system, as a whole, is introduced into the cistern, thereby giving the gas engines cooler injection water.

In Fig. 1 the gas-engine discharge is piped to an open tank or box, elevated above the engine and replacing the conventional funnel. The feed-water heater takes its make-up from a line out of the bottom of this box, the quantity of water being controlled by a float valve at the heater. This box is further provided with an overflow which leads to the sprays or other cooling device at the cistern or pond. To provide against stoppage of the gas-engine circulating pump, the heater should be provided with another float valve which will admit city or service water to the heater, but this float should be set to operate at a lower water level in the heater. Thus the heater will receive hot gas-engine water for all the make-up required, when the same is available. When there is no water available from the gas engines, the heater will automatically be supplied with city water.

Another arrangement is shown in Fig. 2, which the writer has employed where the water supply, on account of its hardness, could not be used in the raw state for either gas engine cooling or for boiler feed. A water-softening plant discharges directly into the cistern, which also acts as a storage for softened water. In this case the gas-engine discharge line runs from its open funnel discharge back to the spray nozzles at the cistern, the funnel being high enough to provide head for spraying the water. The cistern is 12 ft. deep, its top being 6 ft. above, and its bottom 6 ft. below grade. The feed-water heater takes its supply from a steam-driven service pump whose suction is connected to the cistern. Were the system operated as described thus far we would have the afore-mentioned waste of heat, viz., cooling gas-engine discharge water from 130 deg. to 80 deg. before admitting it to the feed-water heater. The gas-engine discharge line and the service pump suction line are, however, cross-connected, and in this connecting line is installed a loop or "inverted syphon" as shown, extending 8 ft. below grade or 2 ft. below the bottom of the cistern. There is, of course, a foot valve on the service pump suction line in the cistern.

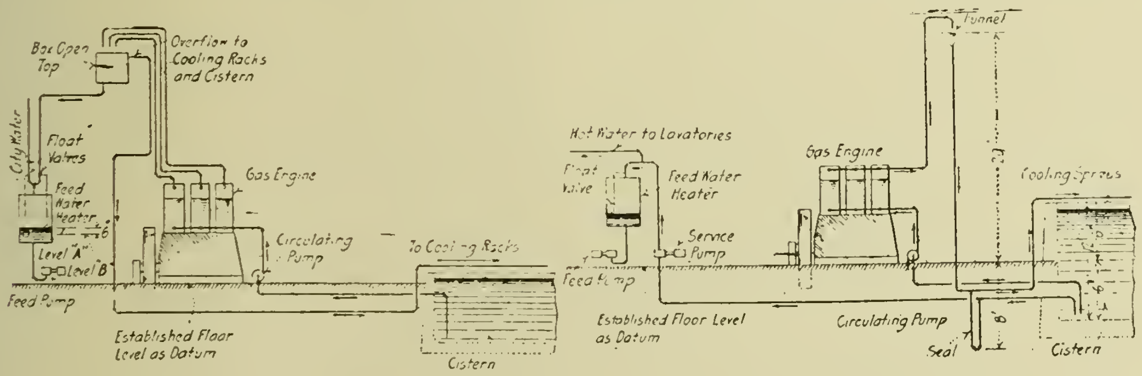



Fig. 1. Saving Heat in Gas-engine Cooling Water. Fig. 2.

The operation is as follows: When the gas engines are running, the service pump receives its supply direct from the gas-engine discharge line due to the fact that this water is offered at a greater head or pressure than cistern water. When the gas engines are shut down, the service pump automatically takes cistern water, the inverted syphon maintaining a seal against admission of air to the pump suction.

Both of the above arrangements are in use, and have resulted in marked reduction of the amount of steam supplied the heater to bring feed water up to a proper temperature. Actual figures in one instance showed an increase in the temperature of the water entering the heater which varies from 75 deg. Fah. to 132 deg. Fah.—*Electrical World*.

# THE INSTITUTION OF MECHANICAL ENGINEERS.

## ANNUAL REPORT OF THE COUNCIL.

On December 31st, 1915, the total names on the roll were 6,319. In 1916 there were 311 additions and 383 deductions, of which 80 were by death, leaving 6,247 names of all classes on the roll. His Majesty the King has conferred honours upon a number of the members, including a baronetcy to Mr. Alfred F. Yarrow, and various appointments to the Companionship of the Order of the Bath, the Companionship of the Order of the Star of India, the Membership of the Royal Victorian Order, the Distinguished Service Order, the Military Cross, the Distinguished Service Cross, and the Albert Medal. Twenty-three members, associate members, and graduates have been killed in action or died of wounds.

For the year ended December 31st, 1916, the total revenue was £22,444 1s. 8d., while the expenditure was £12,628 18s. 11d., leaving a balance of revenue over expenditure of £9,815 2s. 9d. The total investments and other assets amount to £137,588 10s. 7d., and, deducting therefrom the £34,025 of debentures, a temporary loan of £6,000, and other liabilities, including the sum set aside for the leasehold redemption fund, the capital of the Institution amounts to £75,691 12s. 6d. The loan from Messrs. R. and H. R. Williamson has been reduced by another £1,000; and the total leasehold redemption fund has been increased to £19,083 8s. 11d.

The Thomas Hawksley Gold Medal for 1917 has been awarded to Mr. Daniel Adamson for his ppaer on "Spur-Gearing," and a premium of £10 has been awarded to Second-Lieutenant Robert W. Fenning, R.E. (T.), B.Sc., D.I.C., for his paper on "The Composition of the Exhaust from Liquid-Fuel Engines." The third award of the Starley Premium for the best paper published in the proceedings of 1914, 1915, and 1916, dealing with the development of road locomotion, has been made to Mr. Robert E. Phillips, for his paper on "Variable-Speed Gears for Motor Road-Vehicles." The fourth award will be made in February, 1920. The fifth award of the Water Arbitration Prize for the best paper published in the Proceedings of 1915 and 1916 dealing with certain specified subjects connected with water has been made to Mr. Walter Clemence, for his paper on "Theory and Practice in the Filtration of Water."

A declaration of trust for the Bryan Donkin Fund has been prepared and sealed by the Institution. In clause 4 it sets forth that the income of the fund is to be devoted to grants in aid of original research in the science and practice of mechanical engineering. Mr. A. H. Barker, the recipient of a grant from the Fund in February, has procured the apparatus for his research "to investigate a new method of determining the radiant temperature and air temperature in a room." The experiments are being conducted at University College, London, and the results will be embodied in a paper to be submitted to the Institution. The next award will be made in February, 1919.

The Institution examinations were held in October. Ten candidates passed the graduateship and eight the associate membership examination. On the results of the associate membership examination a prize of the value of £5 was awarded to Mr. L. H. Thomas. The examination papers have been printed in pamphlet form. The next examinations will be held in October, 1917.

In January a conference of representatives of the five leading British engineering institutions was held at the Institution of Civil engineers, to consider generally the Government scheme (July 23rd, 1915) for the organisation and development of scientific and industrial research, and the constitution of the advisory council. On the recommendation of the conference a petition was presented to H.M. Privy Council urging that the advisory council should be strengthened by the addition of some representatives of engineering industries. The petition having been declined, a further conference was held, at which a deputation was appointed to wait upon the Lord President of the Privy Council, Lord Crewe, and put forward some considerations as to the representation of engineering on the advisory council. The deputation was courteously received by the Lord President, who explained that the Privy Council did not at that time see their way to modify the constitution of the advisory council.

It was officially announced later that a charter had been granted to "The Imperial Trust for the Encouragement of Scientific and Industrial Research" (hereinafter referred to as the Government Department of Research). Dr. Dugald Clerk, F.R.S., vice-president, was appointed to represent the Institution on the engineering committee of the Government Department of Research. Grants for one year have been made in aid of three researches carried out under the direction of the Institution, namely: Alloys, £200; Steam Nozzles, £300; and Hardness Tests, £100.

In view of the work now being undertaken by the Government Department of Research, it has been considered desirable to take no further steps with regard to the proposal to form a general engineering research committee for the collection and co-ordination of engineering research.

Investigations into the alloys of aluminium with zinc and copper, under the direction of the Alloys Research Committee, have been continued at the National Physical Laboratory, but the publication of the eleventh report has been necessarily deferred until after the war. A grant of £200 towards the prosecution of the research during the year 1916 was received from the Government Department of Research, and this sum, with a like amount from the Institution funds, has been handed over to the National Physical Laboratory. The committee has been enlarged by the appointment of Mr. John Dewrance, member of Council, as chairman, in place of the late Sir William White; Sir Gerard A. Muntz, Bart., member of Council; and Mr. William Mills member.

The Hardness Tests Research Committee, under the chairmanship of Dr. W. Cawthorne Unwin, F.R.S., have carried on their investigations at the National Physical Laboratory with the object of measuring the resistance to wear on rolling or sliding surfaces and comparing it with indentation hardness. A testing-machine of a new type was designed by Dr. T. E. Stanton, F.R.S., and a number of specimens of steel were tested, including samples kindly supplied by Sir Robert Hadfield. The first report of the committee contained the results of experiments made by Dr. Stanton and Mr. R. G. Batson, associate member, together with appendices by Dr. Unwin, Sir Robert Hadfield, Dr. A. E. H. Tutton, and Prof. T. Turner. The Government Department of Research granted a sum of £100 for this work, and a grant of £10 was made by the Council as part of the third award of the Bryan Donkin Fund. During the discussion of the report Sir Robert Hadfield expressed his desire to offer, through the Council, a prize for a new and accurate method of determining hardness of metals. The offer has been gratefully accepted.

The Steam Nozzles Research Committee have still under consideration the design of apparatus for conducting experiments relating to the action of steam passing through nozzles and steam turbines. Some experiments, using jets

of compressed air in a cage designed by Mr. H. M. Martin, are referred to in the discussion of Captain T. B. Morley's paper, and some further trials with this cage have been made. As already stated, a grant of £300 has been received from the Government Department of Research towards this work, and £10 has been granted by the Council from the Bryan Donkin Fund. Captain H. Riall Sankey, C.B., R.E., member of Council, has continued to act as chairman; and Prof. A. L. Mellanby, D.Sc., member, and Prof. J. E. Petavel, F.R.S., member, have been appointed members of the committee.

Although the work of the Wire Ropes Research Committee has been delayed on account of the war, further proposals for the testing-machine have been under consideration, and alternative modified designs are now in preparation.

Mr. Richard Williamson, member, has offered to the Government Department of Research £500 towards a mechanical engineering research, to be conducted by the Institution. The best way of utilising this generous gift has received consideration, and the members have been invited to make suggestions for such a research.

With a view to assisting the maintenance and extension of British engineering trade after the war, the British Standards Committee have determined to translate their specifications into French, Spanish, and Russian, to give metric equivalents of English measures, and to issue the specifications at a much lower price than has hitherto been possible. Arrangements are being made to establish local committees in overseas and foreign countries, to obtain information and facilitate commercial transactions. The cost will be large, and an appeal was made to the institution for a contribution to the fund which is being raised. The matter is considered so urgent that the work is already in hand. It was resolved to grant a sum of £500 as a donation to the fund, the Council feeling that this work is of vital importance to British engineering firms.

The Council have been glad to give their support to a report on the education of the marine engineer, drawn up by a committee of the Liverpool Engineering Society. The efforts of this committee were directed to raising the standard of the marine engineer, both as regards theory and practice. The report is being submitted to the Board of Trade.

Advisory committees have been duly constituted by the Council to give advice and to make representations on matters affecting the members in India and South Africa respectively.

## STEEL-CASED BOILER SETTINGS.

In many generating stations far too little attention is given to housing properly the apparatus that must absorb the heat produced by the furnaces. Boiler settings usually consist of a lining of firebrick built up round the boiler, outside of which ordinary brick is erected, and the whole painted with one of the various heat-resisting paints. The aim is to provide a strong wall that will prevent the escapement of heat and the influx of air. When a setting is not in first-class condition the thermodynamic efficiency of the furnace may be materially reduced because of the radiation losses occurring through the setting and by lowering the effective temperature of the fire resulting from the excess air, or air of infiltration as it is called—that is, air drawn in through cracks and crevices in the setting through joints between the bricks and defective clean-out doors, and even through the interstices of the brick.

The radiation loss for a boiler is practically a constant one for all loads, increasing slightly at loads above normal or full-load rating and decreasing somewhat for lighter loads. The radiation of a boiler having settings of firebrick is a very real and rather variable quantity, being about 3 to 5 per cent for the average size of boiler and setting. If the radiation loss is taken as 4 per cent at full load it will be 8 per cent at half load and 16 per cent at quarter load: hence the desirability of decreasing this loss wherever possible.

Leakage in the setting should also be watched. This is best done by analysing the flue gases periodically, and keeping record of the $CO_2$, CO, and O found in them. By the use of two Orsat analysing outfits or equally satisfactory meters, one placed in the top of the first pass and one just before the back damper at the top of the last pass, it is possible to determine whether the gases are being diluted by excess air drawn in through the setting, bad joints, porous brick, cracks, and crevices.

In an Arizona mining district there is a very interesting installation where radical steps have been taken to reduce radiation and infiltration losses. The plant burns oil fuel and supplies power to a copper-mining company. This plant operates continuously 24 hours per diem and with a very high load factor. Under these conditions economy of fuel consumption is imperative. In the endeavour to accomplish this the boiler settings have been encased in steel. The setting consists of high-grade firebrick, supported by iron or steel supports, outside of which is built a sheet-steel casing. The use of high-grade brick having high heat resistivity or high thermal insulating properties, and the steel casing which makes the setting practically airtight, has effected an increase of efficiency at full-load rating of several per cent, while the efficiency at loads of 50 and 75 per cent is even higher than at full load by from 1 to 2 per cent. In any boiler with ordinary settings the ratio of radiation loss generally increases at such a rate at light loads that the efficiency drops, although the boiler absorption efficiency increases due to the more effective absorption of heat, from which the very real gain due to encasing the brick setting in sheet steel is obvious.

The cost of such a casing should not add materially to the initial cost of the boilers, and would soon pay for itself with the customary load factors met with in central-station practice. In fact, the use of such a casing seems particularly beneficial to central stations, because they usually operate boilers at ratings in excess of normal over the peak load periods, and then, when the peak is over, bank their fires. Sudden temperature changes work havoc with a boiler setting, whereas high temperatures long sustained do far less damage. Forcing a boiler and then dropping the load and banking the fire is about the most severe service to which a setting could possibly be subjected, and will cause cracks and crevices to form, followed by air infiltration, with all that accompanies it. The steel casing for boiler settings, therefore, deserves careful consideration as a means of effecting economies of operation and maintenance.—R. I. Elkin in *Electrical World*.

Institution of Civil Engineers.—On Monday, March 12th, at 5-30 p.m., the first of a series of special extra meetings was held. The subjects chosen for these meetings are matters of special importance to engineers at the present time, and a discussion will follow each of the lectures. On March 12th Mr. Edgar Crammond lectured (under the Vernon-Harcourt Trust) on "Foreign Trade and its Relation to the Investment of Capital Abroad"; and at the later meetings the subjects will be: "Decimal System of Coinage, Weights, and Measures," and "The Standardisation of Engineering Materials."

# BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

*(Continued from page 212.)*

HEAT TRANSMISSION.

## Circulation in Vertical Tube Boilers.

Another group of water-tube boilers have the tubes quite vertical, and although the use of such boilers is not by any means so extensive in this country as is the use of the types previously described, yet, from the point of view of water circulation, they have much to commend them.

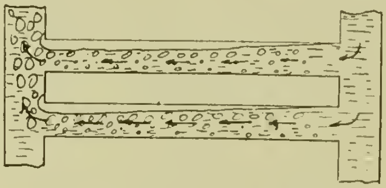


FIG. 88.—BOILER-HOUSE EFFICIENCY.

The natural direction of movement of heated water and steam is vertical, as also is the natural direction of the colder feed water. It will be remembered that the original experiment of Williams, described in a previous article (*Industrial Engineer*, October 7th, 1916, Fig. 70), and which illustrates the true principles of water circulation, were made with two vertical tubes attached to top and bottom headers. In one tube the heated water and steam moved upwards, whilst in the other the cool feed water moved downwards. It will be found that almost all experiments referring to water circulation in tubes have been made with the tubes vertical.

Figs. 88 and 89 show the movements of the water and steam in horizontal and vertical tubes.

In the horizontal tube, if the general movement of the water is from back to front, as shown by the arrows, the position of the steam and water will be as indicated. The steam generated on the surfaces will tend to rise to the top portion of the tube, and also the water movements in the tube, apart from the general movement, will be vertical. Steam will accumulate at the top side of the tube, and the mixture will move together into the front header and mingle with the streams from other tubes feeding into the same. It is evident, therefore, that the water movement is not the natural one due to the application of heat, that the

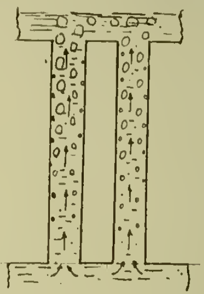


FIG. 89.—BOILER-HOUSE EFFICIENCY.

release of the steam from the generating surfaces and from the water is not provided for in the best possible manner, and further, if any sediment is deposited it will tend to settle on the lower portions of the tube rather than fall and accumulate in correctly-situated drums not subject to intense heat.

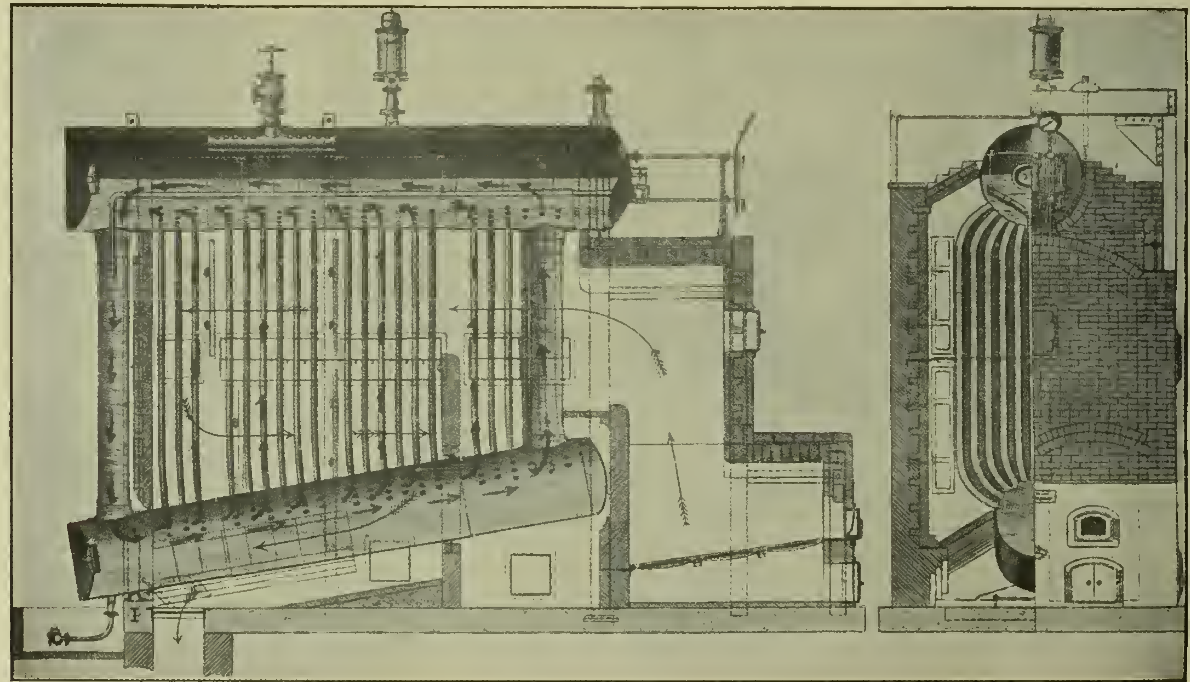


FIG. 90.—BOILER-HOUSE EFFICIENCY

Consider now what happens in the vertical arrangement of tube. In the risers the general movement of the water is exactly that due to the application of heat. The natural movement of the steam is also similar, and its release from the plate surface is assisted by the water movements in the best possible manner. Scale cannot accumulate on the plate, but drops naturally into the bottom mud drums. In the down-

comers the colder feed water easily and quickly gets to the steam generating surfaces, and keeps these well "wetted."

With boilers arranged with vertical tubes there is an absence of headers and their attendant evils.

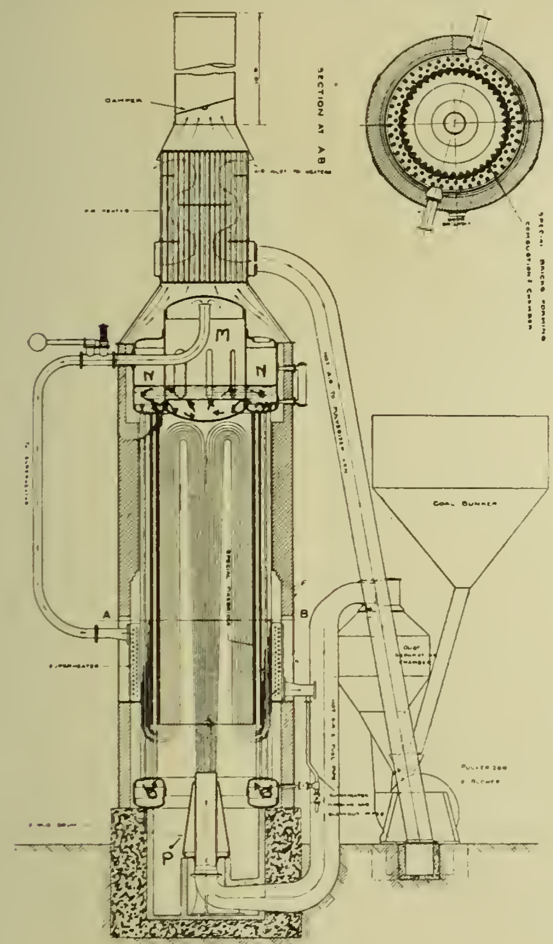



Fig. 91.—Boiler-House Efficiency.

## The Suckling Water-tube Boiler.

In Fig. 90 is shown the design of the Suckling water-tube boiler, in which all the tubes are vertical. It will be seen to consist of a main steam and water drum connected together at the front and back by a large tubular connection, and at intermediate points by a large number of tubes of small diameter.

The water movements are quite simple and natural. Water and steam rises in the large front tube, and in all the small tubes. The water passes along to the back end of the steam drum, and down the large tubular connection at the back, into which also the feed water passes as shown.

The bottom drum is inclined, so that all sediment from the small and large tubes will gradually settle down to the bottom end, and can easily be blown out.

It will be noticed that the main back connection or downcomer is outside the brickwork, and not exposed to the direct heat of the gases. The reason given for this is that by keeping this downcomer cool it will assist in increasing the efficiency of the remainder of the boiler heating surfaces, and thereby produce rapid circulation. In view, however, of Yarrow's experiments, in which circulation was shown to depend on the total heat applied to risers and downcomers alike, there does not appear to be any advantage in keeping the back connection in the boiler in question outside the brickwork.

## The Bettington Water-tube Boiler.

Fig. 91 gives a section of the Bettington vertical water-tube boiler, as used for burning powdered coal. It consists of a main steam drum M, to which is attached the annular ring N. The vertical tubes are secured at their top end to N, and at the bottom end to the annular water drum O. The feed water passes into the bottom chamber O, which is connected with the mud drum P, which in turn forms a water-jacket round the tuyere. From O the water rises through the inner, and possibly the middle row of tubes to the top drums. The heat generated in the combustion chamber with this boiler is so high that the inner ring of tubes has to be protected by special firebricks shown in the section. Steam and water also rise from the bottom of the main drum M, and the water passes over into the ring N, joining the water coming up the inner tubes, and together flow down the outer ring of tubes into the water drum.

It will be noticed that in this boiler, both the risers and downcomers are subject to the heat from the gases, and consequently a quick circulation will result. In addition, there is the direct action of the heat on to the main drum N, so that it is not surprising that in the boiler at the Johannesburg municipal central power-station, which is of 35,000 lbs. evaporative capacity, steam can be raised from the cold boiler in about 20 minutes. In this boiler the heating surface of the boiler proper and the economisers is 6,340 square feet, which gives a normal evaporation of about $5\frac{3}{4}$ lbs. of water per square foot of heating surface.

Fig. 92.—Boiler-House Efficiency.

In this boiler, as well as in the one previously described, there is a large and even steam liberating surface. The rising streams of water and steam from the inner tubes meet with no resistance to steam liberation in their passage.

Owing to the quick natural circulation, no scale can accumulate on the tube, but all deposit falls naturally into the mud drum P.

### The American Wickes Water-tube Boiler.

In America, the use of the vertical water-tube boiler has been quite common, even for high evaporative duties. Possibly the reason for their use may have been connected with questions of floor space, but still the results obtained of their evaporative capacity and efficiency have justified the adoption of this type.

Fig. 92 shows one of the best-known American types, known as the Wickes water-tube boiler. It consists of a steam and water header connected by vertical tubes. The circulation of the water is upward through the tubes at the front, and which are exposed to the hottest portion of the fire, and downward through the tubes at the back.

*(To be continued).*

## THE STEAM SEPARATOR.

The steam separator generally works on the principle that the water particles are heavier than the surrounding steam particles, and, being carried along with the steam, they have therefore greater momentum. If the direction of flow is changed suddenly, the water particles will tend to continue in a straight line, and can be collected in the lower part of the separator body where there is no velocity and whence the condensed steam can be trapped off. Other types are so constructed that the wet steam is given a whirling action, and the heavier water particles are thrown to the outside and allowed to drain quietly to the bottom. Even in these separators the direction of flow is usually reversed. Both of these types of separators are quite effective in removing moisture and in providing the engine with commercially dry steam, especially in the case of high-pressure steam.

However, the direction of flow cannot be changed suddenly, nor can the steam be given a whirling motion without the expenditure of a certain amount of its energy, and the effectiveness of a pound of such steam in a turbine is decreased by exactly this amount of wasted energy. It is true that in the average case this may be a very small percentage of the total energy; nevertheless, it is energy lost.

How can this water be removed from the steam without whirling or reversing action? In studying this problem one must keep in mind the true action of wet steam flowing in a pipe. The wetness of the steam may be due to two factors—the actual water of condensation, flowing generally along the walls of the pipe, and the minute suspended particles of vapour resembling fog in the flowing steam. Condensation due to radiation losses takes place principally on the walls of the pipe, and there is no logical reason why the moisture resulting from this condensation should permeate the steam that is flowing at the centre of the pipe.

Some years ago, after observing the performance of wet steam and superheated steam passing through a glass pipe, a noted engineering professor advanced the theory that the moisture due to condensation all adheres to the pipe and flows along the bottom if the velocity is very low, or in spirals about the pipe if the velocity is sufficiently high or after bends or elbows. This opinion was verified later by a series of tests on a large main of a heating system. A small search tube was employed having a single hole that could be adjusted to any position in the pipe. It was found that either water or very wet steam passed along close to the sides of the pipe, while the inner core of steam was practically dry. The depth of the film of wet steam along the walls of the pipe decreased with increase of the steam velocity.

If such is generally the action occurring in straight piping, then all that should be necessary is to provide some device that will allow the inner core of dry steam to pass through directly, and only the outer ring of wet steam need be carried to a separating chamber, which in its simplest form may be a modification of a water-leg. There is probably considerable mixing of steam and water in elbows, but where long-radius bends are used it is probable that the water still sticks to the edge of the pipe, especially along the outer radius of the bend.

When one is dealing with low-pressure steam, the question of steam separators is very important. In one of the large Western plants, in which low-pressure steam turbines are used with Corliss engines, considerable difficulty has been experienced in securing dry steam from the separators. In the discussion of the recent paper by Messrs. Stott and Finley, on the tests of the Interborough's 30,000 kw. cross-compound steam turbine, it was pointed out that the efficiency of the turbine was improved over 1 per cent by removing all the baffles from the separator, which had been placed between the high- and low-pressure cylinders. In this case the steam from the high-pressure cylinder carries its moisture in the form of fog, and it cannot therefore be efficiently removed. The separator also offered such a resistance to flow that the energy represented by a drop in pressure of 2 $^{8}/_{10}$ in. of mercury was lost in overcoming it. Some large turbines using two cylinders, but of later design, have no separators at all, for the steam passes directly from the high-pressure cylinder into the low-pressure cylinder.

It is therefore in order to suggest to engineers that some attention and study be given to the types of separators in use in their plants and to improved means of dealing with moisture in wet steam. The complete separation of moisture from low-pressure steam is still an unsolved problem for engineers.—*Power.*

## ENERGY WASTE IN BOILER MAKING.

A sort of analogy has been drawn between bricks and boilers in order to show that as the laying of the former has been almost trebled in a test by the elimination of superfluous motions, it may be possible to cheapen the building of the latter by removing any energy waste in the costly item of riveting. The principle is quite simple. No muscular effort must be expended on anything which is unnecessary for the job. Our knowledge of hod-carrying, mortar-spreading, and brick depositing is not sufficiently technical to enable us to judge between the old order of things and this new dispensation of bricks, but we are quite sure that no comparison is possible with the repeatedly interrupted work of hand riveting. This is such a costly item of the workshop that anyone who can specify any means of effecting economy without loss of efficiency may be sure of widespread interest, especially as hand riveting still holds its place for water-tight work against the completion of machine-driven hammering. Vainly we searched for anything tangibly-helpful in lowering labour costs. All that we managed to cull from the subject related simply to a facile arrangement of the workshop and not to the motions of the men engaged in the work. The net result is so

elementary and trite that we are dubious about tendering the advice to adults. For instance, where two different fuels are equally suitable it is cheaper to use the lower-priced one. It is also better to use the right forge in the right place, than to use a wrong one somewhere else. We cannot say that these enlightening counsels, even when assisted with so many thousands of bricks, will send us much further along the road to perfection. Yet we are convinced that in many workshop operations, including boiler-making, a waste of energy occurs in non-productive movements. That obdurate animal, the British workman, is not always willing to be cured of this source of loss, even when piecework—that mixture of good and bad elements—tempts him to a truer expenditure of energy, and consequently we think that the fullest amelioration can be attained only when he is properly coached in the early stages. Teach the apprentice rightly, and the habit will remain.—*Page's Engineering Weekly.*

## THE INSTITUTION OF AUTOMOBILE ENGINEERS.

Beginning this year, 1917, and continuing until further notice, there will be awarded at the discretion of the Council of the Institution, an addition to the Graduates' Prize offered each year, a premium of £25 to the graduate who submits the best paper on an appropriate subject in any session.

Papers must reach the Secretary of the Institution during the month of September in each year, and the award will be made known during Christmas week in each year.

This annual premium has been placed at the disposal of the Council by the Daimler Co. Ltd.

A meeting of the London graduates of the Institution of Automobile Engineers was held on February 22nd, when a paper on "Factories: Their Building and Organisation" was read by Mr. H. O. Blackford.

The author first dealt with the question of suitability of site, and went on to emphasise the necessity for forethought in planning a factory with a view to possible extensions rather than, as is often the case, extending merely in the line of least resistance. It was also desirable to eliminate the unnecessary conveying of parts from one end of the factory to the other, and this could best be done by methodical planning of the shops. As far as possible a works should be mapped out with each of the shops carefully designed for its individual requirements and its arrangement in relation to its immediate neighbours should be such that a minimum of labour is required in moving parts from one operation to another.

The second part of the paper dealt with the question of the staffing of factories, and special attention was given to the consideration of apprenticeship systems, a plea being made for more careful placing and supervision of apprentices. The main staff was then discussed and the author strongly advocated the establishment of an active technical board (apart from the board of directors), specially appointed to meet at frequent intervals to check and consider the various details of the concern. This Board should include representatives from all departments, including buying and selling. The importance of smooth working between departments such as the shops and the drawing office was emphasised, and attention was drawn to the importance of the sales department and its function as the link between the works production and the public.

The duties of the chiefs of the various departments were briefly outlined, and the author concluded with a reference to the necessity for specialising on output on a large scale in this country. The conclusion of the war would provide an opportunity of turning over a new leaf, much too valuable to be lost.

## ELECTRICITY METERS.*

By J. Rennie.

The earlier forms of meters recorded coulombs, the pressure being assumed at a constant value. When it is preferred to associate the pressure and the current in the measuring operation, the instrument becomes an energy meter.

In a motor meter, the electrical energy drives the rotor of the meter, and so operates a recording train giving the record. But in order that the rotation shall be directly proportional to the driving power at any instant, an opposing or regulating device is included. In the earliest meters a rotating vane, by air friction, was used. The plan which is now almost universally adopted is a metal disc, the rotor moving between the poles of one or more permanent magnets and producing the regulation according to the well-known Barlow's wheel, or Foucault-current brake. In the case of the alternating-current meter, the disc rotor is used both to produce the driving power and the Foucault-current regulation.

In the electrolytic meters the measuring devices take various forms. It may be a liquid decomposable by the electric current, and the decrease in bulk of the electrolyte is shown on a scale graduated in units of energy; or the liquid may be electrolytically transferred from a reservoir to a measuring vessel, which gives a means of assessing in energy units the amount that has been decomposed in a given time. Of the meters in use, the largest proportion are of the motor type, with a comparatively small number of electrolytic.

In direct-current energy meters the rotor was drum wound to carry the pressure circuit, and the magnetic field was produced by one of the various ways of arranging the current circuit suitably. It was desirable that this current should be as small as possible, to reduce the energy lost in the meter; hence the large resistance added suitable for the pressure employed. The construction and the metal used for the commutator and the brushes have throughout continued troublesome questions. Silver was found very unsuitable for our climate, gold was tried, and then a wash of platinum. The choice has favoured silver more than anything else, combined with such a form of brush as kept clean and maintained the conducting pathway across the commutator bars. The driving spindle, usually vertical, carried a disc rotating between the poles of permanent magnets and producing the regulation required.

Points which called for care and attention were the form of the added resistance; the preparation of the permanent magnets and the volt drop in the current circuit of the meter. As for the resistance, the manufacture passed through the various vicissitudes of haphazard, or any how winding, to an ordered form, in which the winding was disposed so as to minimise the possibilities of short circuits, which had an effect on the accuracy. Then the wire being wound in separate sections, there was less

* Abstract of an address delivered to the Association of Supervising Electricians.

risk of pressures greater than perhaps 15 or 20 volts between any two contiguous wires.

The drop in the current circuits of meters required the reconciling of opposing claims. In the first place, a large drop gives a large driving power, and with it the presumption of better accuracy, and perhaps more hardiness. But large drop means loss of watts, and the problem has always been finding just the least driving power that will serve for the accuracy required.

For a suitable driving arrangement for alternating current meters, an attempt was made to modify one of the arrangements already in use for direct-current meters, practically, a small ironless dynamo; this was easily managed by winding the added resistance non-inductively. But there was still involved the commutator. Very soon the inductive plan—Ferraris motor—was adopted, and eventually led to a most admirable type of meter.

That is not to say, however, that the problem of a suitable meter was at once and for ever solved. The production of two magnetic fields and of two currents with a phase difference between them was, comparatively speaking, easy; but when this had to be done within the small compass of a meter case, in the most economical fashion, and in the way best suited for the purpose of a reliable measuring instrument, there arose a most interesting, if slightly puzzling, problem. It involved, for instance, the question of producing a suitable choking coil; methods of controlling and regulating variations due to change of frequency, and to change of pressure; variations in temperature; methods for the use of the current field; and its disposition towards the field produced by the pressure.

A detailed examination of the different kinds of alternating-current meter is not necessary for our present purpose, and on this part of our subject I shall confine myself to certain outstanding features.

As an example, a certain type of meter had a mechanical adjustment which was operated by moving horizontally a certain piece fixed in position by a screw, this screw being small and so lightly held that it could be slackened by using the thumb nail as a screwdriver. This invited criticism, because any chance involuntary movement of a screwdriver or the fingers might unconsciously change the adjustment. The screws in such a case should always be hard home, to secure permanence, so far as that adjustment is concerned.

The screws used in the adjusting should preferably not be small or of the watchmaker type. Those for the connecting cables should be strong and serviceable, with not too quick a pitch and able to stand, without stripping, the use of a reasonably-sized screwdriver. Where a magnetic gap is employed, it is advisable that the faces of the gap should be machined. There have been instances, in which for convenience, the ends of the laminations were not even trimmed but left ragged, forming uneven surfaces. This unevenness would not of itself be objectionable, except that on such surfaces there is always a risk of material collecting and lodging, and it is surprising how much magnetic material there is about.

I would also mention a matter which is not now so frequently met with, a pressure coil in which the connection is provided by simply leaving out a sufficient length at each end of the wire. In our climate there is always the liability to electrolytic corrosion at the point where such wires emerge from the body of the coil, and it is also there that a bending strain is applied on making and breaking connection; hence the frequent result that a break happens at the most inconvenient place for repair. It is advisable on this account to make the first and last four or five turns of comparatively thick wire, say, Nos. 18 or 16, and to bring out sufficient lengths of the thicker ends to make the connection. Further, the usual precautions should be taken to safeguard the bending risk at the exits from any winding.

In the 1882 Electricity Act, provision was made for measurement and, as I think, great wisdom was shown in the method adopted. It was practically left in the hands of a State department, the Board of Trade, to establish such Rules and Regulations as might from time to time be necessary or advisable. The effect of these Rules or Regulations could be re-considered and altered as occasion showed necessary, without further Parliamentary action, which might have proved a very great inconvenience.

The system established by the Board of Trade under the meter clauses of the Electrical Lighting Clauses Act, 1899, may be briefly summarised as follows: The value of the supply was to be ascertained by an appropriate meter, duly certified, etc. A certified meter was to be a meter of a type that had been approved by the Board of Trade, and found accurate by an inspector appointed under the special Order.

The first requirement was securing approval for the type of meter. For this purpose, three or more specimens were to be submitted to the Board of Trade for examination and test, as they might from time to time deem desirable. When a type had been approved, a specimen was sealed and retained by the Board of Trade, together with a specification and suitable drawings. Any meter exactly similar to such specimen and of a range included in the approval, might be sealed by an inspector as a certified meter, provided that he had ascertained by test that it was a correct meter. The word "correct" was left undefined until 1909, when a definition was embodied in the Electric Lighting Act of that year. From the beginning, the accuracy required for approval was 2 per cent, plus or minus, from one-tenth load to full load, whilst for certification, the accuracy was $2\frac{1}{2}$ per cent; and these figures were well known to all concerned. A subsequent clause in the same 1899 Act requires the undertaker to supply through an appropriate and certified meter to any consumer who may so demand it.

The general effect of this was to leave the meter question almost entirely in the hands of the undertakers, and, for a time, applications for approval were very limited. Makers did not find that approval was any great assistance to their sales. Further, the requirements of the Board of Trade for approval becoming more generally known, it was seen that a specification for meter contracts might with advantage be reduced to a couple of lines, stating that the instruments were to be of type approved by the Board of Trade. By the year 1908 requests for approval became more frequent and increased at a growing rate until the advent of that general disturber of the peace, the present war.

These requirements in their final form, are grouped in three divisions. Division A includes matters of construction (looking at the instrument as a machine); Division B has special reference to the electrical features; and Division C to the accuracy.

Requirements under A and B would be merely matters of inspection but for the fact that, even at this late date, correspondence or conference is nearly always required upon details. Sometimes experiment is needed, but not usually prolonged. In the early specimens, it appeared,

less consideration was given to the electrical than to the mechanical part. For instance, in the matter of insulation, it was not always remembered that the atmosphere in this country is never favourable to insulation, and is sometimes actually destructive of it. Again, in winding a circuit, it was often necessary to criticise forms and methods. Perhaps only in this division of the requirements did clash of opinions arise. In one case a meter was, on the part of the makers, held back from approval because of their unwillingness to change the method of winding the added resistance. Even in that case, however, they subsequently found it useful to conform to the requirements, which had meanwhile acquired the undoubted support of the meter trade generally.

In dealing with the third division, C (accuracy), experimental work is, of course, necessary, and at times somewhat lengthy, for a reason which you should know. When a meter has received the approval of the Board of Trade under the Electric Lighting Acts there is not, apparently, any known power for revoking that approval. A case arose in which, some time after approval had been given to a certain meter, difficulties emerged, and the makers, after a lengthy investigation, produced a new type. They applied to have the original approval revoked, but that was found impossible, and their only course was to withdraw the meter from sale. For this reason the examination in respect of division C of our requirements, and to a slight extent with regard to B as well, has to be done with an eye to the possibility of changes occurring through the flux of time and ordinary usage.

But there is still another influence affecting the meter and its record, the onus of which must be laid on your shoulders and upon those of the consumer. I mentioned very briefly certain circumstances attendant on the position occupied by a meter. It is possibly not usual to find magnetic effects in the neighbourhood of an ordinary household meter, but do not forget that they exist. Possible vibrations of the support must certainly be remembered. Also temperature and moisture. Temperatures may be higher than the normal, and changes of the temperature may also be greater than the normal. Dampness on the wall or in the neighbourhood of the support is to be avoided wherever possible. The errors due to the circumstances which I have mentioned can certainly be greatly decreased if in installing a meter you can secure their avoidance.

Again, there is the question of lighting and convenience of reading. I am strongly of opinion that much latent inaccuracy in meter reading and in instrument reading generally is to be traced to insufficient illumination of the dials or scales, and to their positions making the reading a difficult and awkward job. The dials may be too high above the eye level, and too low, making it difficult to get down. The instrument itself is by no means unsightly, and I have never understood why it should be relegated to the coal cellar—to anywhere, in fact, provided it be out of sight and out of mind. This is altogether a wrong notion; do try to change it.

A large number of electricity meters have been submitted to and tested by the Board of Trade, and of these these the construction and pattern of 77 different types were approved from 1891 until the present date.

The total of 77 includes 32 of foreign manufacture and 45 of home manufacture. The 45 of home manufacture were submitted by 10 British firms and the 32 foreign by eight foreign companies or by their agents here. No notice has been taken of repeated improvements on approved types, which were accepted and included within the original approval in each case.

Further, 30 of the meters were for measurement on direct-current circuits and 47 for alternating-current circuits. Of the direct-current meters 10 were of the motor type, and of the remaining 20 all were electrolytic. There were 11 of type in which mercury was used and nine used other electrolytics; hence the electrolytic principle operated in two-thirds of all the direct-current meters. Two of the mercury meters and one of the electrolytic were prepayment.

Whatever might be the future of meters, it will, I think, always be desirable that every meter in a company's circuit should be tested at periodic intervals. As a beginning, the interval should not exceed three years, and preferably one year, but as time passes, and experience of the various types accumulates, one might lengthen the period. So far as present experience goes, probably the time interval, five years, under the Meter Laws in Canada, is the maximum.

And, now, having said so much about electricity meters, let me whisper the dreadful query, "Why electricity meters?" Is it necessary to add to the other expenses in the production of electricity those further of providing meters, installing, reading periodically and accounting?

If it could be shown that a meter in the house provides an opportunity for the undertakers obtaining knowledge of the circumstances of the consumption, then something might be said for the perpetuation of meters. But it must be remembered that the same object—control for the circumstances of consumption—is attained in the case of the distribution of water. A "stopcock" is an official who provides exactly the same control as we suppose the meter readers provide.

The number of electricity meters now on circuit in this country cannot be much short of three-quarters of a million, and if we take them at the round figure of, say, 30s. each, they represent a capital outlay of £1,125,000. Probably, four or five years represents the accurate life of a meter, and we might estimate that at the end of 10 years renewal was necessary. Let us take the depreciation as £110,000 per year, a moderate estimate.

Further, to keep the meter up to its accuracy, extensive repairs and adjustments will be necessary at the end of every third or fourth year.

Hence it would appear that for all accounts less than £10 per annum the interposition of a meter adds about $2\frac{1}{2}$ per cent to the bill, and for economy's sake there is much to be said in favour of dispensing with the meter.

As the amount of the bills for electric energy taken by the consumer increases to £50 or £100 the relative outlay concerned with each particular account becomes of less importance to the account, and whether its interposition is justifiable is a question to be argued on other grounds.

Spring Steel.—Spring steel is said to become brittle when used as cathode in a hot cyanide solution, either sodium cuprocyanide or simple sodium cyanide. The effect is more pronounced with the simple salt. Brass and phosphor-bronze are not affected. Brittleness is not produced by the liberation of hydrogen on the steel. The carbon content is not changed by the electrolysis. The crystalline structure is not changed by electrolysis. The brittleness is not produced in annealed wire; the brittleness is produced by use as cathode whether the wire is coiled or not bent in any way. The brittleness is not produced when the wire is used as anode, or when it is suspended in the solution without the passage of electricity.

## COAL AND ITS CONSUMPTION.*

By W. H. Casmey.

There is probably not one person present who did not read as a youngster the story of Aladdin's Wonderful Lamp, by the rubbing of which the fairies were called, and, no matter what the wish expressed, it was at once complied with.

We have, however, to-night a bigger marvel than Aladdin's Lamp to discuss, namely, coal, and although its looks are not interesting, it probably contains more surprises than any other known substance, and we might copy one of our scientists and call it "bottled sunshine." Geologists tell us that millions of years ago, long before man's time, the earth was covered with dense vegetation, and that by some means this, in course of time, was buried, and due to the earth's pressure and chemical action it solidified and formed what we now term coal.

### A Modern Aladdin.

The chemist is our modern Aladdin, and by manipulating the coal he takes from it the warmth and light which vegetation received from the sun in the ages past; and, further, he secures from this black mass the lovely colours and perfumes of the pre-historic flowers, and also the very honey they contained. The energy given by the sun to the trees and plants is also brought to life again, as, besides light and heat, the chemist gives us from one ton of coals:

Motor spirit, 2 to 3 gallons.
Light oils, 4 to 6 gallons.
Heavy oils, 6 to 9 gallons.
Pitch, 80 lbs.
Sulphate of ammonia, 20 lbs.
Coke, 15 cwt.,

and also some of our most powerful explosives. Without coal the industrial world would come to a stand. By means of coal big ships are carried to all parts of the earth; over 1,400 million people are fed and clothed; it has removed distance, as we can have breakfast in Yorkshire, and midday lunch in London. It supplies us with books and newspapers, and it gives to our Armies and Navy the big guns and shells, and all fighting tackle required; in fact, coal may be considered as the condensed energy of the whole earth.

Our ancestors, 100 years ago, sang of the wooden walls of England, their grand old ships, but this Black Magician has replaced the oak with steel, and instead of being dependent for movement on the erratic winds, our Dreadnoughts of over 40,000 tons can rush through the strongest gale at 25 miles per hour, and the explosive taken from the coal, and above referred to, can throw a shell of a ton in weight over 20 miles. Aladdin's Lamp of fancy is certainly far behind our plain, simple coal of reality.

Seeing then the important part which coal plays in the world, does it not seem strange that although we have used it in this country hundreds of years, we are still in the elementary position of considering how it can be used more economically, and especially as nothing will yield greater, nor is there anything more amenable to common-sense handling.

### The Output of Coal.

We may gather some idea of the magnitude of our subject when we consider our annual output of coal is nearly 300 million tons, over 50 million tons of which is used for domestic purposes, over double this quantity for our various industries, and the remainder for our railways, marine purposes, and for export. An expression 300 million tons conveys nothing to the mind, but if we consider Great Britain as having an area of 200,000 square miles, say 400 by 500 miles, the coastline would be 1,800 miles long, and our annual coal output is sufficient for building a wall around the United Kingdom, 1,800 miles long, 30 yards high, and 3 yds. thick. Due to the large number of men who have joined the colours, our coal supply has decreased about 30 million tons, hence the imperative reason for the national attempt to reduce the coal consumption as far as possible.

### Some Effects of Imperfect Combustion.

With the outside air fouled by the products of imperfect combustion, it is impossible to flood our schools, factories, and workshops with the necessary conditions for maintaining the combustion of the body, and it is this negligence which contributes largely to our death-rate of over 40,000 per year from consumption and similar diseases. Science has made typhoid, typhus fevers, and smallpox almost impossible, and we are so devoted to our sanitation that we do not care to drink from the same glass as another person, and yet we appear to raise practically no objection to breathe over and over again the products of combustion from other people's lungs, and which, in the first instance, was fouled by our carelessness by the products of imperfect combustion from our furnaces.

From a long practical experience, I am satisfied that a saving of from 10 per cent to 15 per cent could be quite easily effected without adopting any drastic measures, and such an economy would mean a saving of from 30 to 40 million tons per year, or say 100,000 tons per working day.

### How Can a Saving be Effected?

To reply to this question, "How can this saving be effected?" is merely to remember we stoke with air as well as coal, and this fact once realised, economy follows as surely as day follows night. Consider, however, a moment what an economy of 30 million tons of coal would mean to the nation. If exported, it would bring approximately 40 million pounds sterling into the country, but if the coal was not required it would at once liberate over 30,000 men for other purposes, and would minimise railway congestion by taking 10,000 wagons and 250 locomotives from the various lines daily. From another point of view, it would give us a purer air to breathe, thus securing an improved public health, the minimising of fogs, increasing the comfort of travelling, reduction of municipal expenses, and would allow fully one hour per day more sunshine in our large towns. This brief outline clearly indicates the national importance of special attention being paid to the subject of burning coals more economically than at present, and whilst not questioning that the ultimate will be to gasify all fuel on account of the valuable by-products, we must to-night deal only with the present conditions. We will divide our subject into three sections—cause, effect, and remedy, and as the last mentioned is of the greatest importance, we will deal with the first two but very briefly.

### Cause.

The cause of fuel wastage is due to neglecting to give in the boiler-house the same careful attention as obtains in every other part of a works; in fact, there is generally no consideration for the boiler-house so long as steam pressure is maintained. Undoubtedly, the primary cause of losses is to be found in giving either too little or too much air,

* Lecture given before the Spenborough Institute, Cleckheaton, November 4th, 1916, by W. H. Casmey (Holdsworth & Sons, Boiler Makers, Bradford).

defective brickwork, furnaces too large for the outlets from furnace flues, side and bottom flues too small, stoking at the wrong time, and being guided by the steam-gauge instead of common sense, the final results being furnace temperature too low for igniting the liberated gases, and which consequently pass away as black smoke. During the last three years, two engineers. D. Brownlie, B.Sc. Hons. (Lond), F.C.S., and H. Green, have carried out evaporative and efficiency tests on over 100 steam plants in different parts of the country, and including all the principal industries, and our methods are so bad that 70 out of the 100 had efficiencies averaging only 60 per cent, say, out of every £5 spent in fuel only £3 was accounted for by the boiler. As it is possible to take 100 works, and find such wasteful conditions, it may be very naturally assumed such conditions are in evidence all over the country.

### Effect.

The effect of any boiler attendant not carrying out the elementary laws of combustion is to give himself unnecessary work, to waste his employer's money, to flood the atmosphere with dust, soot, and foul gases, to lay the foundation of our winter fogs, with their long train of expenses and inconveniences, and to very materially increase the death-rate. It would take hours to deal with the effects in detail; we will therefore consider one item alone, and that only briefly, but one which affects the greatest number of people, namely that of fouling the atmosphere. We are compelled to breathe the air by which we are surrounded, and as health is governed by the quality of the air, the value of this being kept pure is most apparent. The law of combustion which governs our furnaces applies to the human body, and the point cannot be brought home too strongly that fresh air is absolutely essential if health and energy are to be maintained.

### Dr. Chalmers said at a Meeting in Glasgow.

"In 1874 and 1875, after seven weeks of frost, the death-rate rose to 67 per thousand, half of which was due to lung diseases. The winter of 1909 was remarkable for the recurrence of dense fog extending over several days, with an interval of a few weeks between them. The average annual rate of 18 deaths per thousand rose to 25, and during one week the rate was 33 per thousand, again the same diseases predominating. If doubt remains in our mind as to whether or not our wasted fuel plays such a serious part, we need only to think over the following facts. In the Attercliffe district of Sheffield, in 1914, the average monthly fall of dust per square mile was 56 tons, or at the rate of 672 tons per year; in the Hillborough Park district 288 tons during the five months, October to February, 1914. The dust fall in various towns was as follows:

| | Tons. |
|---|---|
| Oldham | 440 |
| Central Birmingham | 326 |
| Bolton | 288 |
| Liverpool | 273 |
| Manchester | 220 |
| London | 211 |
| York | 131 |
| Malvern | 29 |

From Leeds and Bradford approximately the same results were found as in the Manchester and Liverpool districts. The quantity of soot and dust falling in the industrial areas being nearly 20 times as great as in the suburban districts."

### How Fog is Formed.

In concluding this section, let us consider how fog is formed. Due to the heat, moisture, and dust given off in our towns, the air begins to rise, but in doing so cooler air from the surrounding districts flows in to fill its place, and is in turn increased in temperature and rises, and as a higher elevation is reached the temperature begins to fall. Now note the effect: Assuming the air had a temperature of 40 deg., and contained the normal percentage of moisture—82 per cent—and it is reduced in temperature 10 deg., this increases the weight by one grain each cubic foot, and as the reduced temperature also increases the percentage of moisture, condensation follows and appears either in the form of fog or rain. If the temperature fall is not sufficient to produce rain, then the tiny particles of dust sent through the chimneys act as a condensing medium, and a dense, opaque mass of fog is produced. The dust and moisture-laden air begins now to settle down, owing to its increased weight, and reverses the inward flow from the surrounding country, and as products of combustion are constantly being added to the atmosphere, the density of the fog increases, spreading for miles around. With a greater reduction in temperature, however, rain may be produced which will be quickly followed by wind, and the fog bank is broken up and the stagnant mass of impurities cleared away, but the black, greasy pavements which are left behind speak loudly. From actual analysis we also learn that the gaseous and solid impurities found in the atmosphere in foggy weather are the same as found in products leaving our furnaces, hence our confidence in the statement that black smoke and other products of imperfect combustion are responsible for fogs.

*(To be continued.)*

# New Companies Registered.

BRITISH MARINE ENGINEERING CO. LTD. (146,217).—Private company. Registered February 27th. Capital, £30,000, £1 shares. Engineers, launch builders, manufacturers of storm governors and other appliances for regulating engines, propellers, and machinery, etc. The subscribers are to appoint the first directors. Registered office: 71, Finsbury Pavement, E.C.

PALL MALL ENGINEERING CO. LTD. (146,306).—Private company. Registered March 2nd. Capital, £2,500; 1,000 10 per cent cumulative preference shares of £1 each and 6,000 ordinary shares of 5s. each. Ironfounders, engineers, manufacturers of motor engines (land and marine) and accessories, electrical engineers, etc. Agreement with A. Watling. Directors: A. Watling and E. A. Digby (both permanent). Solicitor: H. P. Beecher, 26, Bedford Row, W.C.

SUN FUEL CO. LTD. (146,250).—Private company, Registered February 28th. Capital, £50,000, £1 shares (25,000 7½ per cent cumulative preferred). Manufacturers of and dealers in patent fuel, colliery owners, coke manufacturers. Directors: A. E. Allen and W. Wood. Registered office: 529-31, Salisbury House, London, E.C.

WIRELESS TELEGRAPHY ON BRITISH SHIPS.—By an Order in Council, issued on July 28th last, every British ship of 3,000 tons gross or upwards is required to have a wireless installation. Negotiations were opened with the Marconi International Marine Communication Company and shipowners in regard to the general conditions for supplying installations, but the details of the agreement are being left to individual shipowners to settle. Subsequently modifications of the agreement were found to be desirable and are now being discussed. Licences are only issued by the Post Office (under the direction of the Admiralty) as and when it is found possible to obtain the apparatus and operators.

## Trade Items, Notes, &c.

New Engineer-in-Chief. Mr. J. B. Ball, engineer-in-chief of the Great Central Railway, has been appointed chief engineer of the London, Brighton and South Coast Railway, in place of Mr. C. L. Morgan, who has retired on becoming a director of the Brighton Company.

New Shipyard. According to the Amsterdam correspondent of the *Morning Post* a new company, the Pommernwerft, has been formed in Berlin to take over and develop a site at Poelitz, near Stettin. It is expected that work will be begun next year, when freight steamers and passenger vessels of 4,000, 7,000, and 10,000 tons will be built, as well as motor vessels.

An All-British Steel Syndicate. It is announced that prominent steel-makers throughout Great Britain are considering a scheme to form an all-British syndicate of steel-makers, with a view to shutting the door effectively against foreign steel-makers on the conclusion of the war. The merchants on their part have formed themselves into an association to safeguard their interests.

The Institution of Automobile Engineers. Commencing this year (1917) and until further notice, there will be awarded, at the discretion of the Council of the Institution of Automobile Engineers, in addition to the graduates' prize offered each year a premium of £25 to the graduate who submits the best paper on an appropriate subject in any session. Papers must reach the secretary of the institution during the month of September in each year, and the award will be made known during Christmas week in each year. This annual premium has been placed at the disposal of the Council by the Daimler Company Limited. Further information can be obtained from Mr. Basil H. Joy, secretary of the Institution, 28, Victoria Street, Westminster, S.W.

State Control of Mines.—The Advisory Board to assist the Controller of Coal Mines has been constituted as follows.

*For Coalowners.*—Messrs. Adam Nimmo, A. Pease, C. L. Rhodes, Bramwell, and Sir Thomas Ratcliffe-Ellis.

*For Miners.*—Messrs. R. Smillie, W. Straker, H. Smith, S. Walsh, M.P., and Vernon Hartshorn.

The Controller will confer with the Board on general questions of policy affecting the industry. For the present the existing general and local committees will be continued, but the more direct control of the industry will probably call for changes in the existing organisation.

Engineering Wages. Important awards have been made by the Committee on Production (Sir Geo. Askwith, Sir David Harrel, and Sir Geo. Gibb) as to wages in the engineering and shipbulding trades. The increased amount given by the present awards, which apply to all federated engineers and shipbuilding firms in Great Britain, is 5s. per week, payable as from April 1st, and 2s. 6d. per week to boys and youths. The awards apply to timeworkers, pieceworkers, premium bonus workers, etc., and the amount awarded is stated to be intended to assist in meeting the increase in cost of living. In the award for the engineering trade there is a provision that in districts where the advances in time rates since the beginning of the war amount to less than 7s. per week a further advance is to be given sufficient to bring the amount up to 7s. The addition of the 5s. now awarded thus brings the war advances to timeworkers in those trades up to not less than 12s. per week. The pieceworkers in those trades, as in the shipbulding trades, have already received an advance of 10 per cent on piece rates as a result of findings of the Committee on Production, and they are now to receive in addition the amount of 5s. given to timeworkers. Over a million workers are affected by the above award.

Standardised Ships. Sir Leo Chiozza Money, in a written reply to a House of Commons question put down by Mr. Pennefather, says that the programme of standardised cargo shipbuilding which is being carried out is designed, under expert advice, to produce for the national use, in the shortest possible space of time in the given circumstances, vessels specially designed to meet the conditions of war, and it is not the case that these standard ships have been substituted for vessels which are equally suitable. The standard programme is not one of disorganisation; on the contrary, it is a method of organisation which economises time, material, and labour. In reply to another question, Sir Leo Chiozza Money said that the standard ships which are being built to the order of the Ministry of Shipping are the property of His Majesty's Government. It may be pointed out that Germany is at present making great efforts in order to enlarge her merchant fleet, and has imitated the British plans for the building of ships of a special standard type. A large new dockyard has been established, at which it is intended only to build three types of ships of 4,000, 7,000, and 10,000 tons. It is hoped by this means the cost will be reduced, and that ships can be built in a very short time.

A Proposed Mersey Traffic Tunnel. The project of constructing another tunnel under the Mersey between Liverpool and Birkenhead has been revived. There are two schools of opinion on the subject (says the *Times*), one favouring a traffic tunnel and the other advocating a great bridge. Sir William Forwood, in urging that a traffic tunnel is necessary, estimates that it would cost £1,200,000, with tracks for both slow-moving and fast traffic, but would be less expensive than a bridge as a means of relieving the enormously developed cross-river goods traffic. It is pointed out that the congestion and delay in this traffic under present conditions is bearing hardly on the trade of the port, and that something will have to be done to provide permanent relief, especially in view of the future growth of Liverpool's trade. Sir William Forwood suggests that a tunnel might be approached by a subway with a gradient of, say, 1 in 20, a spiral roadway descending at that gradient 120 ft. or 150 ft. to the mouth of the tunnel. Such a spiral would not occupy more than an acre of land, and there is ample room for its construction at the pier head. The centre of the spiral might be used for passenger lifts, but passenger traffic could also be conveyed in motor or electric trains.

Working Results of the Lake Coleridge Hydro-electric Power Plant.—The results of the first year's working of the Lake Coleridge hydro-electric power plant have, according to the Public Works Statement for 1916 of the New Zealand Minister of Public Works, justified the most sanguine anticipations. The lake, which is some ten miles long, is situated in the Canterbury Province, in the basin of the Rakaia River. Three units of generating machinery were originally installed, capable of an output of 6,000 H.P. Twelve months ago the demand for current warranted the installation of a fourth unit of 2,000 H.P., and the expanding business now necessitates the addition of a fifth unit, comprising pipe-line, turbine, and generator of 4,000 H.P. During the year the maximum load on the plant reached 1,770 H.P., which is less than the capacity of any one of the units installed. Under these circumstances the business could not be expected to show a profit, but, on the other hand, at the end of the year the plant was earning sufficient to cover working expenses. Contracts to the extent of 8,000 H.P. have already been entered into, and when the power under these contracts is being supplied it is confidently expected that the plant will be earning sufficient to pay interest in full as well as working expenses.

Erosive Effect of Steam on Turbine Blades.—An investigation of the erosive effect of steam on turbine blading material has been made at the United States Naval Academy, and the results are given in a recent issue of the journal of the American Society of Naval Engineers. For the purpose of the tests a brass box 9 in. by 9 in. by 7 in. was used, which acted as exhaust chamber and contained the brass blading holders and blades, which were stationary and placed at an angle of 10 deg. to the nozzles in order to avoid the spattering effect. On the front of the box was a steam chest containing expanding nozzles designed for 100 lb. gauge pressure and 27 in. vacuum. Extruded brass, rolled cupro-nickel, monel metal, Parsons metal, and drop-forged steel were tested. The results showed that extruded brass stood up best at 3,400 ft. per second velocity with steam quality of about 87 per cent. Here the loss was 0·121. Monel metal followed with 0·273, and steel with 0·386. Because of difficulty in obtaining the blading material there were dissimilarities in the dimensions of the pieces tested, particularly in the case of the steel specimens. These discrepancies in blading width and thickness vitiate weight losses when determined as percentages of the original weights of the specimens. In the case of steel its width was less, and its thickness considerably less, than that of the other materials. Rolled brass, cupro-nickel, and Parsons metal did not compare at all favourably with the others. In general, there appears to have been no particular uniformity in the amount of erosion during the different periods.

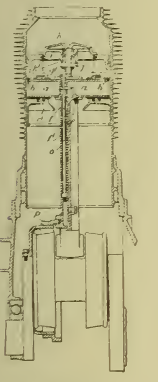
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

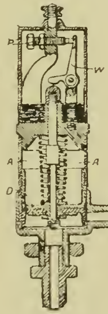
## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

102,707.—H. L. MILNER and A. R. BEEBY, West Park, Kew Gardens, London.—Oct. 31st, 1916, No. 15,540 Addition to 20,013/14.—In a revolving-cylinder engine in which an induction valve in the head of each piston is actuated by a resilient and compressible tappet-rod as described in the parent Specification, the parts *f*, *f*1 of the tappet-rod are connected by a single spring *o* normally under tension, and the tubular part *f* passes through the gudgeon pin *a*, which rocks in bearings *b*. The gudgeon pin *a* is locked to the connecting-rod by a set-screw *e*, and the bearing-bushes *b* are lubricated from oil-wells *c*1 formed in the piston. The guide *h* through which the valve stem *g*1 passes, has slots to receive a valve-stem cross-pin *j* engaging arms *k*1 of a pair of pivoted balance weights. The lower part *f*1 of the tappet-rod is actuated positively in both directions by a cam *p*.



Patent 102,707.



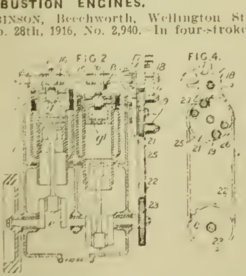
Patent 102,774.

### ENGINE STOP-GEAR.

102,774. J. B. SKEOCH 16, Hambelton Terrace, Glasgow Road, Wishaw, Lanarkshire. Oct. 3rd, 1916, No. 4,937. Relates to liquid-pressure devices for stopping internal-combustion engines provided with forced lubrication, when the oil supply fails. A cylinder A connected to the oil-supply system contains a spring-pressed piston D. When the normal oil supply is provided, the piston is raised, and a lever W is moved so that it is out of contact with an adjustable screw P connected to the ignition circuit. Should the oil supply fail, the spring presses the piston downwards and allows the lever W to come into contact with the screw P and short-circuit the ignition device.

### INTERNAL-COMBUSTION ENGINES.

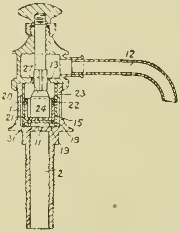
102,852. C. ROBINSON, Beechworth, Wellington Street, Dunoon, Argyllshire.—Feb. 28th, 1916, No. 2,940.—In four-stroke-cycle engines




having movable cylinder heads *g*, *g*1, Fig. 2, each head is provided with ribs 2 working in slots at the upper end of the cylinder and is moved downwards by a cam 6, or an equivalent such as a grooved cam or a combination of springs and a grooved cam or eccentric, acting on a roller 8, and upwards by means of springs 4. The cams 6 are keyed on a shaft *f* which also carries cams 15, 16 for actuating the inlet and exhaust valves, and is worked from the crank-shaft *e* through the following gearing. A wheel 23 is connected by a chain 22 to a wheel 21, on which are mounted two pairs of raw-hide rollers 19, Fig. 4. A quadrilateral wheel 17 and a star-wheel 18 having eight teeth are mounted on the shaft *f*, and the latter wheel is engaged by the rollers 19. The wheel 17 is engaged by a disc wheel 25 secured to the wheel 21 and having notches 26, 27 cut in it, these gears interlocking when the wheel 18 is not in motion. During admission, in any cylinder, the head is at its highest position, and on the next up-stroke of the piston *c*, it remains stationary; but on the following down-stroke, it moves down with the piston until the crank is about 45 deg. from the vertical. Ignition then takes place, and the head remains stationary.

### VALVES.

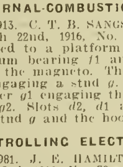
102,884. J. E. COXON, 1,121, Pender Street West, Vancouver, British Columbia, Canada. May 22nd, 1916, No. 7,294.—A self-closing valve, opened by a push and closed by fluid pressure acting on a piston, comprises a valve member 24 with a conical face 27 adapted to engage a seat 13, the valve member being secured to a hollow actuating-piston 21, which also acts as a piston valve and has a small port 31 in its closed end to facilitate the opening of the valve. The actuating-piston works in a



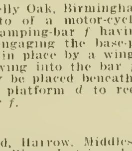
liner 15 held in the lower undercut part of the casing 1 by the upper part, provided with an outlet spout 12. The liner has a transverse partition towards the bottom provided with a hole 18, and holes 19, 20 in the side walls, so that when the valve is open, water entering at 2 can pass through the restriction 11 and holes 19, 20 into a groove 22 provided with holes 23 formed in the piston, and thence to the outlet. The valve member may be of brass or fibre or may have a metal core with a fibre covering.

### BEARINGS.

102,907. W. FOWLER, 27, St. Mary's Road, Doncaster, Yorkshire.—Aug. 31st, 1916, No. 12,337.—A ball bearing having a grooved outer race *c* and a spherical inner race *c*1, which can be tilted to enable the balls to be inserted, is combined with a thrust bearing comprising balls *g* bearing against a flange *e* integral with the race *c*1, and against a ring *f* which is seated spherically in the casing *k* or may be integral with it.



Patent 102,907.



Patent 102,913.

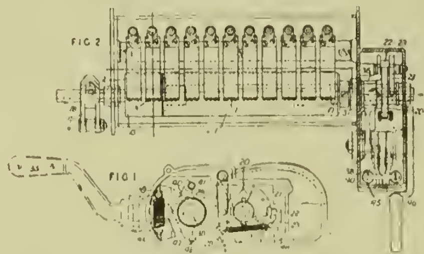
### INTERNAL-COMBUSTION ENGINES.

102,913. C. T. B. SANGSTER, Dale Road, Selly Oak, Birmingham. March 22nd, 1916, No. 13,631. The magneto of a motor-cycle is secured to a platform by means of a clamping-bar *f* having a fulcrum bearing *f*1 and a hooked end engaging the base-plate *e*1 of the magneto. The bar *f* is secured in place by a wing-nut *g*2 engaging a stud *g*, or by a bolt screwing into the bar *f*. A washer *g*1 engaging the base-plate *e*1 may be placed beneath the nut *g*2. Slots *d*2, *d*1 are formed in the platform *d* to receive the stud *g* and the hooked end of the bar *f*.

### CONTROLLING ELECTRIC VEHICLES.

102,981. J. E. HAMILTON, 69, Butler Road, Harrow, Middlesex. Jan. 3rd, 1916, No. 70. In means for controlling electric vehicles, particularly of the type described in Specification 10,325/15, the controller, main switch, and brake are so interlocked that the main switch is disengaged when the brake is applied, and neither can be again moved until the controller is returned to neutral position. The controller drum 1 engages contacts 7 and is secured on a sleeve 17 which turns loosely on a hollow shaft 18, to which is secured a drum 13 engaging contacts 2, 3 and forming the main switch. The shaft 18 is connected by linkage 19 to the vehicle brake gear. The sleeve 17 carries a pinion 36 engaged by a segment 37 on a shaft 38 operated by the

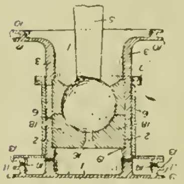
controller handle 35. In order to return the handle to neutral when it is released, the shaft 38 carries a lug 47 which bears between levers 39, 40 connected by strong springs 45, 46 and arranged loosely on the shaft with their ends bearing against fixed stops 41, 42, which also serve to limit the movement of the handle in either direction. The sleeve 17 carries a notched wheel 20 engaged by a roller 29 on a lever 28 connected by a spring 30 to a pawl 23 carrying a roller 22 engaging a cam 48 on the



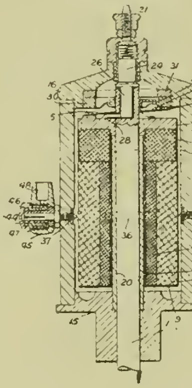

wheel 20 when the handle 35 is in neutral position as shown. A cam 21 secured on the shaft 18 is in the position shown when the brakes are on and the main switch is closed, and the cam 21 is moved downwards to lift the pawl 23 from the cam-surface 48, so that the handle 35 may be operated. If the brakes are applied and the main circuit broken while the handle 35 is out of the neutral position, the pawl 23 falls into a notch 50 in the cam 21, so that the brakes and main switch cannot again be operated until the handle 35 is returned to neutral and the cam 48 lifts the pawl 23 from the notch 50.

**PISTONS: CONNECTING RODS.**

102,982. S. R. BURGESS, 18, Church Road, Epsom, and C. GORDON, 9, Wellington Square, Chelsea, London. January 4th, 1916, No. 108. A piston 1 is made in two parts 2, 3, which are externally-screwed and held together by a sleeve 6 and locking-piece 7, and hold between shoulders 19 blocks 18 engaging the spherical end of the connecting-rod 5. The upper and lower heads 9, 10 are provided with packing-grooves 11, 12, and the upper head is provided with a groove 13 containing a scraping-ring, which removes lubricating-oil from the cylinder and passes it through channels 14 and an intervening space to the space above the piston, which communicates with the ball-and-socket joint by a passage 16.



Patent 102,982.



Patent 102,998.

**INTERNAL-COMBUSTION ENGINES.**

102,998. M. A. CODD, 64, Belvedere Road, Lambeth, Surrey.—Jan. 11th, 1916, No. 477.—An ignition set consists of a rotating coil having primary and secondary windings 11, 12, a condenser 13, a contact-breaker co-axial with the coil, and a distributor in close juxta-position with the coil so as to avoid intermediate wiring. The driving-spindle 1 has one of the platinum contacts 2 clamped thereto, the other 4 being carried by a spring plate 5 attached to the collar 6 which is secured to the spindle 1. An extension 32 on the plate 5 wipes against the recessed underside of the plate 30 in the fixed cover 16, thus making and breaking the contacts 2, 4. The timing is adjusted by an arm which projects from the member 31 through the cover 16. Primary current is led in by the terminal 21, spring-pressed brush 24, conductor 26 insulated in the end of the spindle, and lead 28. The coil spool consists of the collar 6, flanges 7, 9, and a tubular portion 8, the whole being longitudinally split to prevent eddy currents. The cap 15 has screwed into it a tube of soft iron 20, serving both as the core for the coil and as a long bearing, whereby a separate bearing at the contact-breaker is rendered unnecessary. One end of the secondary coil is connected to a metal strip 36 secured in the surface of the coil by a wrapping of ebonite paper and cotton which overlaps a flange on the strip. As the coil rotates, the strip makes contact successively with the points 37 of the distributor terminals. These terminals consist of a split spindle on which screw members 44, 45 with brass bushings 46, 47. The part 45 has a lateral enlargement with a passage 48 for the sparking-plug conductor. Both ends of the secondary coil may be insulated, each being brought to another strip 36, and each plate engaging a set of distributor points so that two plugs, each with one electrode earthed, may be employed in each cylinder.

# INDEX TO ADVERTISERS.



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# EDITORIAL.

## THE BARROW STRIKE.

The strike of engineers at Barrow is a most deplorable action, and is entirely and utterly indefensible on the men's part, whether in war-time or peace-time, and at this particular time is nothing less than acting as accessory to the placing of terrible dangers upon those who are fighting our battles both upon sea and land, dangers which may well lead to increased maiming and loss of life. This is not the kind of thing that any body of men ought to have upon their consciences. In saying what just precedes we do not take up sides either against the men or for those who employ them. We base our condemnation upon the manner in which the strike has been brought about, and not in the least upon the alleged rights of the men or the alleged wrongs of the employers, or *vice versa*. The plain, simple facts, so far as we have been able to ascertain them, are that the shop stewards, on behalf of the men, complain of the operations of a particular rate fixer and the alleged cutting of time allowance for work done under the premium bonus system. The men demand the dismissal of the rate fixer. Now, these are quite legitimate subjects for discussion at any time, and in war-time like the present with a balance leaning considerably to remaining at work. The gross mistake which the men have made is that they have, apparently, acted without first discussing with, or obtaining the consent of, the executive of their union to the action which they have taken. The point is this: that if, as we understand—and it is generally the case—a previous agreement was come to on behalf of the men by their executive with the employers as to the carrying out of methods of work and remuneration, then clearly and logically any alleged deviation from the points of agreement by the employers and those acting on their behalf, should have been the subject of discussion by the men, first with their own executive and thence through such body with the employers.

If the men's executive representatives are good enough to deal with the general and ordinary internal organisation of the details of their own union and to sign working agreements on their behalf in the manner referred to, then surely in the name of ordinary common sense they ought to have been consulted in the case we are discussing. If the men are dissatisfied with their executive that is a question for themselves to remedy, and they should supersede them with the same ruthlessness with which they demand the dismissal of the rate fixer. Their present resort to a strike, without taking the honourable and sensible course which common-sense suggests leads to nothing but chaos in ordinary times, and in war-time like this, when every working hour is valuable, it not only involves chaos in industrial conditions, but the added crimes of unnecessary butchery and murder to boot. We have not the slightest sympathy with this method of settling disputes. Surely, there is nothing in the alleged breach of agreement which could not have been discussed whilst work was proceeding. No matter how bad the rate fixing might be; no matter how obnoxious the rate fixer may be to the men, the only sensible course was to adopt the procedure we have outlined. If, as is alleged, the rate fixer is unbearably obnoxious, that is a point for consideration not only by the men, but by the employers as well, who would be equally guilty of crime in persisting in the perpetuation of methods which were known to be the cause of unrest and strife.

But no matter what the cause of the trouble is, and recognising, too, the long hours and strenuous work put in by the men for the last two years at least, nothing can justify their action in face of the hardships which are undergone at the front and on the raging sea by the brave lads who are defending their country at the miserable pittance of a shilling a day.

# VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.

(*Continued from page 224.*)

## Hydraulic Transmission.

In hydraulic transmission there are two essential elements, a pump (driven by the prime mover) by which the working fluid is put and transmitted under pressure, and by hydraulic motor (by which motion is transmitted to the road wheels of the vehicle) driven by the pump. These two elements are suitably connected, so that by varying the output of the pump per revolution the power imparted to the road wheels can be varied as desired, as if the speed of the engine is kept constant the effect of lowering the volume of liquid pumped is to increase its pressure in the same ratio.

The advantages claimed for hydraulic transmission are: (1) that as all the mechanism is enclosed, and works in oil under pressure, friction is reduced to a minimum, and damage is practically impossible; (2) that a change of speed can be effected without any jar or strain on the prime mover (3) that it is extremely smooth and comparatively quiet in running; (4) that in changing gear there is no necessity to disconnect the prime mover; (5) that the gear can be adjusted to the constantly varying requirements of the prime mover without checking the momentum of the vehicle, and, finally, that it is simple in action, durable, and economical in working.

## Various Types.

The various types of hydraulic transmissions that have been introduced only differ from one another in the type of pump and motor employed and in various details of construction and control, and two of them are described, namely, the earliest—the Hall, Fig. 20—and the latest—the Compayne, Figs. 21 to 27—which is associated with the name of Dr. Hele-Shaw. The practical advantages of the Hele-Shaw system are that the pump has a uniform and steady discharge under all pressures, that sliding friction is reduced to a minimum whereby the total efficiency of the pump is materially increased; that the rotating parts of both pump and motor are perfectly balanced; that there is no end-thrust in either the pump or the motor owing to all the forces being in the plane of rotation; that all the parts are simple, and those that require any great degree of accuracy are cylindrical; that there is a minimum of wear on any of the parts; that although high pressures are employed, no packing glands are required; that owing to the rotary form of the valve the slip of oil past the valves is reduced to a minimum because the oil pressure does not tend to open the valve, and that the inertia forces in both pump and motor are perfectly balanced. It is claimed that a long series of tests of a pump running at 1,000 revolutions per minute show an efficiency of 73 per cent at quarter stroke, of 80 per cent at half stroke, and an over-all efficiency of 90 per cent at full stroke. The mechanical efficiency of the motor is put at 95 per cent, and this efficiency is stated to be largely due to the fact that the motor works at a considerably slower speed than the pump. The combined efficiency of the whole system from engine to road wheels, including the loss in the conducting pipes due to the viscosity of the oil, as shown by trials, averages over 70 per cent at all speeds between 5 and 15 miles per hour, the efficiency at 8 miles per hour being 76 per cent and at 12 miles an hour 72 per cent.

## Electric Transmission.

Electric systems, or, as they are more properly designated, petrol-electric systems, owing to the prime movers employed being of the internal-combustion type, may be conveniently divided into four groups:—

(1) In which the surplus power of the engine is stored in the form of electric energy in a battery of accumulators and is given out when required to augment the power of the engine, of which the Pieper or Auto-Mixte may be taken as an example.

(2) In which the entire power of the engine is converted into electrical energy, which is absorbed continuously by an electric motor driving the road wheels of the vehicle, of which the Stevens may be taken as an example.

(3) In which the electric energy is employed to start and accelerate the vehicle, after which the drive from the engine to the road wheels is transmitted through a magnetic clutch, of which the Germain may be taken as an example.

(4) In which the electric energy is wholly or partially employed to start and accelerate the vehicle, after which the electric drive is cut out and the power is transmitted from the road wheels mechanically, of which the Thomas may be taken as an example.

Details of these four examples are given. Many more or less divergent forms and combinations of these systems have been adopted by various investigators, but they only differ in details of construction and arrangement.

Considerable divergence of opinion exists as to which of these petrol-electric systems is the best, and although it may well be argued that each is best adapted for a particular class of work, there is no gainsaying the fact that the second system is the only one which has been used on a commercial scale for any considerable length of time. The points in favour of the first system are that the surplus power of the engine is being continuously stored in the form of electric energy, which is available for use when the power of the engine requires to be augmented, and that the engine and dynamo run at a constant speed, which enables the former to be run to the best advantage and enables the latter to produce a current of suitable voltage to charge the accumulators at the proper rate.

The points in favour of the second system are, first, its simplicity, as the whole of the power of the engine is converted into electrical energy, which is transmitted direct to the motor driving the road wheels; secondly, the small number of its parts; and, thirdly, as the speed of the engine is independent of that of the vehicle, it can be run at the speed at which it gives its maximum power and efficiency. It is claimed for the Stevens transmission that the over-all commercial efficiency running in normal omnibus service is 79 per cent, and that said efficiency arises chiefly from the great economy both in petrol consumption and in general upkeep. The factors which make for economy in petrol consumption are the slow speed of the engine as compared with the speed of the transmission shaft, and the ability of the vehicle to free-wheel *i.e.*, run without propulsion, for a considerable part of its running time; while the factors which make for economy in upkeep are: (1) the simplicity of the transmission in which no gear-wheels, no clutches, and no battery are employed; (2) the absence of transmission stresses due to the elasticity of the electrical drive; (3) the absence of clutching and de-clutching

as obtains in mechanical gearing; and (4) the non-braking of any electrical circuits during driving. This system has been used in the Tilling-Stevens omnibuses and other public service vehicles for several years. In the London service alone these omnibuses have run over 6,000,000 at an estimated cost of 7·132 pence per mile; while in the running of over 3,000,000 miles on solid rubber tyres in the London service of omnibuses an average of 20,148 miles per tyre has been obtained.

The advantages claimed for the third system as compared with the first or second systems are, first, that when the load is within the capability of the engine the drive between the engine and the road wheels is practically, though not absolutely, mechanical, at which time the electrical losses are reduced to a minimum; and, secondly, that the mechanism can be used for braking purposes. Against these, however, is the serious drawback that mechanical means has to be employed from the reverse, in addition to which the double commutator adds to the complication of the control. It is also claimed for this system that, as the electrical equipment is used solely, or mainly, for starting and accelerating, the equipment can be made comparatively smaller, lighter and cheaper; but this would seem to be a fallacy, as the output of the electrical equipment cannot be confined to starting and accelerating duties only, for the simple reason that occasions must arise when more power than can be obtained on the direct drive will be called for, thus making it necessary to use the electric transmission. As this is the most severe duty that the electrical equipment can be called upon to perform, it must be of such proportions as will propel the vehicle during the whole working period without over-heating if trouble is to be avoided.

As regards the fourth system, this is considered more economical than a direct electrical transmission, but against this must be set off the complications which arise from the introduction of the planetary gear and the clutches. The Thomas transmission has undergone two trials under the auspices of the Royal Automobile Club. The first trial was with a 36-H.P. Leyland lorry over a distance of 2,008 miles, the running being continuous day and night. The weight of the lorry unladen was 4·502 tons, and the weight of the load, including passengers, 3·181 tons, making a total of 7·683 tons. The running speed was not to exceed 12 miles per hour, and averaged (running time only) 10·47 miles per hour; the fuel consumption worked out at 7·555 miles per gallon, giving 58·046 ton-miles per gallon calculated on the gross weight and 24·030 miles per gallon calculated on the net load. During the trial no work was done upon the transmission with the exception of lubrication, for which $5\frac{1}{2}$ ozs. of oil were used, and at the end of the trial the whole of the transmission, with the exception that the teeth of the double helical planetary wheels were somewhat worn, and two brushes, four sparking tips, and one brush contact point were sufficiently burnt to require renewing, was in good condition. The second trial was with a 12-16-H.P. Delahaye car from London to Edinburgh and back, in which test the fuel consumption was approximately 35 miles to the gallon, giving 67·9 ton-miles per gallon. An omnibus fitted with this transmission and running in a regular service in London has given from $10\frac{1}{2}$-11 miles per gallon of fuel. It would therefore seem that the claim that this system is more economical than the direct electrical system is well founded.

### Hall Hydraulic Gear.

In the Hall transmission, Fig. 20, three radially-arranged pumps A are employed, the plungers $A^1$ of which are operated through connecting-rods by a common crank B on the shaft V, which is driven by the prime mover. Three radially-arranged motors C are also employed, the pistons $C^1$ of which are operated through connecting-rods by a crank D on a non-rotating shaft E, which is arranged eccentrically in relation to the driving shaft V. Both the pumps A and the motors C are carried in a common casing F, which is free to rotate about the axis of the driving shaft V and is coupled to the driving road-wheels through suitable gearing. The cylinders of each pair of pumps and motors are connected by ports controlled by valves G and H, the valves G of the pumps being operated by an eccentric J on the driving shaft V, and the valves H of the motors by an eccentric K, which is loosely mounted on and in relation to the driving shaft V, and is provided with means whereby it can be rotated through a given arc. The shaft E, although non-rotating, is capable of a limited amount of rotation—through the worm L and the worm-wheel M—in order to adjust the eccentricity of the crank K. The shaft E carrying the crank D is carried in an eccentric bush or bearing N, the eccentricity of which is equal to the throw of the crank D, so that when the crank is turned so that its greatest throw coincides with the greatest eccentricity of the bush or bearing N the crank will be concentric with the shaft V and will then act merely as a fixed axle and impart no movement to the pistons $C^1$ of the motors C as the casing F rotates. The eccentric K on the driving shaft V, which operates the valves H of the motors, has an extension O which is toothed internally and engages a spur-pinion P carried on

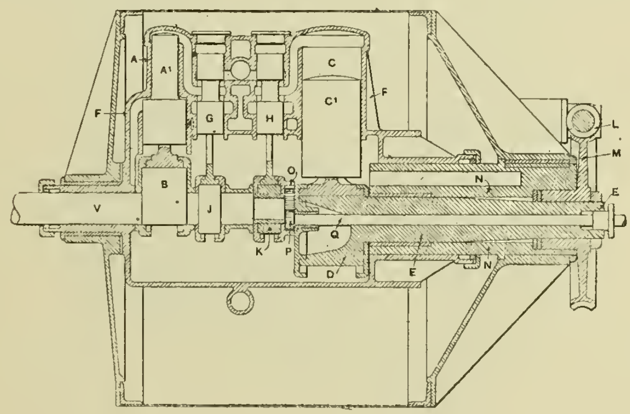



Fig. 20.—Diagram of Hall Hydraulic Gear.

a shaft Q, which passes centrally through a hole in the shaft E. The shaft Q is provided with suitable means of rotation exterior to the casing F, so that the position of the eccentric L can be altered in relation to the crank D. By this means, in a manner similar to that of the well-known form of loose eccentric reversal employed in marine engines, the direction of rotation of the casing F can be reversed when required. The whole of the spaces, passages, and cylinders of the casing F are filled with oil, which is constantly pumped by the pumps A through the valves G and H to the motors C, the capacity of which exceeds that of the pumps.

The action of the apparatus is as follows:—Upon motion being imparted to the driving shaft V, the pumps A operate to pump oil into the back ends of the cylinders of the motors C, which thereby impart rotary motion to the casing F, the ratio of speed between the driving shaft and the casing being determined by varying the centre of the crank operating the pistons of the motors with respect to the axis of the driving shaft. When the cylinders of the motors are working to their full capacity the greatest reduction of speed is obtained, and inversely when they are working at their lowest capacity the highest speed is obtained, the casing F then rotating at the same speed as the driving shaft V. If, as in the construction illustrated, the capacity of the motor cylinders is four times that of the pump cylinders, when the crank of the motors is in the position to impart the greatest amount of movement to the pistons of the motors, it will take four strokes of the plungers of the pumps to fill the cylinders of the motors with oil, and consequently the shaft V will have rotated four times during

the time the pumps have by filling the motors caused the casing F to rotate once, but as in normal working shaft V and the casing F rotated in the same direction one revolution of the pump shaft is lost for each revolution of the casing, so that the shaft V is geared down in relation to the casing F in proportion of 5 to 1. As before stated, when the crank D is concentric with the shaft V there is no movement of the pistons of the motors, and consequently the whole apparatus is carried round at the same speed as the shaft V, and the highest speed of rotation is imparted to the casing F. In this condition there is no circulation of the fluid in the apparatus, and except for the connecting-rods of the motors turning upon the crank D and the rods of the valves H moving upon the eccentric, there is no relative movement of the various parts of the mechanism. It will be understood that the two positions of the crank D before described are the two extremes, and that any intermediate position of the crank and consequently variation of the proportions of speed and power of the whole apparatus can be obtained by rotating the crank D.

## COMPAYNE HYDRAULIC GEAR.

The essential feature of the Compayne transmission is the Hele-Shaw pump, Figs. 21 and 22, which by reason of its construction can not only be run at a high speed without vibrations, but has a high degree of efficiency. The construction and action of this pump—which is of the rotary plunger type with a plurality of cylinders—will best be understood by reference to Figs. 23, 24, and 25, which are diagrammatic sections through the pump at right angles to its axis. The cylinders A (of which there are seven in the construction shown) are formed in one block with a sleeve which is mounted on a fixed stub axle B, this sleeve being coupled to a shaft S which is

Fig. 21.

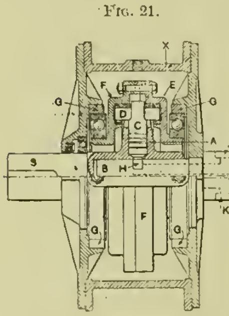
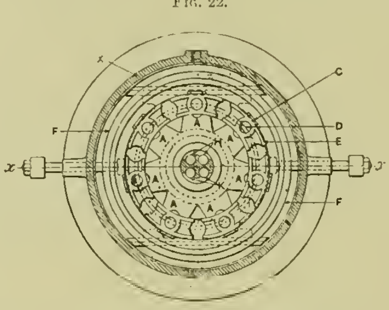


Fig. 22.



Figs. 21 and 22.—Hele-Shaw Pump. Compayne Hydraulic Gear.

driven by the prime mover. The pistons C carry gudgeon-pins D, which pass through slots in the cylinders and engage with slipper pieces E which fit in two opposed grooves in a drum F, which is mounted in ball-bearings to rotate in a housing G. The grooves in the drum F form paths for the gudgeon-pins, and the drum F operates as a floating ring, the action and operation of which in relation to the pistons is that of a series of connecting-rods. The housing G is mounted to slide transversely across the casing X in suitable guides. By displacing this housing in the casing X in relation to the stub axle B on either side of its vertical centre line, that is to say, along a horizontal line *xx* passing through the centre of the said axle, the eccentricity of the path of the gudgeon-pins with respect to the cylinders can be varied for the purpose of varying the stroke of the pistons, and therefore the output of the pump as a whole. As the acceleration of the slipper pieces and pistons above the centre line *xx* is balanced by the retardation of similar parts below the centre line, all the inertia forces are balanced.

The drum F is kept full of oil by centrifugal action, and no oil is allowed to accumulate in the casing X, whereby all churning of the oil is avoided. In the stub-axle B, about which the cylinder block revolves, are two ports or groups of ports, H and K, with which ports in the bases of the cylinders A coincide as they revolve, said ports being in communication with similar ports or groups of ports, $H^1$ and $K^1$, at one end of the axle B exterior to the casing X by means of suitable passages. When the block of cylinders revolves, the floating ring F revolves with it, as the resistance of the slipper-pieces E is greater than that of the ball-bearings carrying it. In the central position the slipper pieces have no movement, and in any other positions they only move to and fro to an extent directly proportional to the stroke of the pistons. If the cylinders are rotated in the direction of the arrows, and the path of the gudgeon-pins is concentric with the axle B, as in Fig. 23, no motion is imparted to the pistons, and therefore the pump is inoperative. If the path of the gudgeon-pins is moved to the left, as shown in Fig. 24, the pistons as they move above the centre line *xx* move outwardly, and therefore tend to create a vacuum, so that the oil is forced into the cylinders either by atmospheric pressure or by an artificial pressure in a supply-tank through the ports $H^1$ and H, while the pistons

Fig. 23.

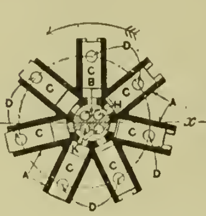


Fig. 24.

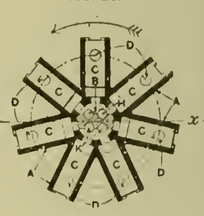
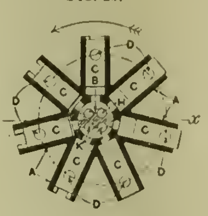


Fig. 25.



Figs. 23 to 25.—Diagrams of Hele-Shaw Pump. Compayne Hydraulic Gear.

as they move below the centre line *xx* move inwardly and discharge the oil from the cylinders through the ports K and $K^1$, the ports $H^1$ and $K^1$ being connected by suitable piping to the hydraulic motors. If the path of the gudgeon-pins is moved to the right, as shown in Fig. 25, the pistons move outwardly when moving below the centre line *xx*, and inwardly when moving above the said line, so that the flow of the oil is reversed without altering the direction of rotation of the cylinders, the ports $K^1$ and K becoming the suction ports and the ports H and $H^1$ the delivery ports. In moving from the position of maximum delivery on one side to that on the other side, the discharge is gradually reduced until the central position is reached, when the delivery ceases, after which it again increases to the maximum with the flow in the opposite direction, the change from full forward to full reverse discharge being made without shock, the flow at all times being proportional to the eccentricity of the path of the gudgeon-pins.

The hydraulic motor, Figs. 26 and 27, is of a similar construction to the pump, but is of the constant-stroke type and works inversely. The novel feature of the motor is the employment of a cam as a track for rollers carried by the gudgeon-pins. Two motors are usually employed, arranged either one in each road wheel or both mounted on the chassis and each driving one of the road wheels by means of chain or other

Fig. 26.

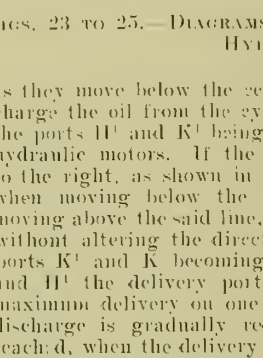
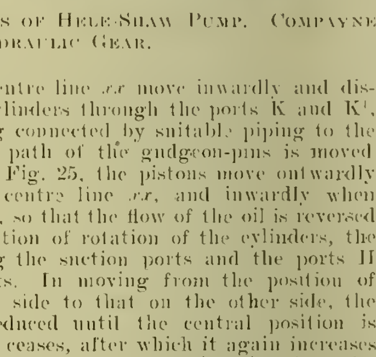


Fig. 27.



Figs. 26 and 27. Hydraulic Motor. Compayne Hydraulic Gear.

gearing. The gudgeon-pins D carried by the pistons C carry ball-bearing rollers M at their ends, which travel within a double cam N formed in or carried by the casing Y. Owing to the shape of the cam, the pistons make two strokes per revolution. This gives a complete balance of the working parts, an absolute and uniform turning movement, and obviates any shock in the system. By arranging the cam and the valve shaft so that they can both rotate at relatively different speeds, and making the cam of a corrugated or wavy form, a single revolution of the motor can be obtained from any desired

number of strokes of the pistons of the pump. This enables a very great turning effort to be secured without unduly increasing the proportions of the motor.

PIEPER ELECTRIC SYSTEM.

In the Pieper, or Auto-Mixte, system, which is practically the same as the earlier British system of Farrow, a shunt-wound dynamo is mounted on a shaft which couples the engine with the road wheels through a magnetic clutch and suitable transmission gearing. The dynamo is connected through a controller with a battery of accumulators, and works either as a motor or a dynamo, according as its electromotive force is inferior or superior to that of the battery. The dynamo is fitted with commutating poles, the windings of which are connected in series with the armature, thus ensuring good commutation with heavy currents and with a weak main field. The battery, although primarily employed for assisting in propulsion, can also be used for starting the engine and for ignition purposes. The supply of explosive mixture to the engine is controlled by the demand for current from the accumulators through a differentially-wound solenoid, so that during starting and the period of extra effort the discharging current traversing its series winding decreases the magnetism produced by the shunt winding, which in turn increases the supply of mixture, and thus compels the engine to give its maximum power for a given number of revolutions per minute. When the dynamo is charging the cells, the action of the series-winding assists that of the shunt-winding and tends to close the throttle. When the power of the engine is below that required, the battery automatically supplies energy to the dynamo, which then operates as a motor. When the power of the engine is in excess of that required for traction, or when the kinetic energy of the car can be recuperated, that is, when the car is slowing down or is running on a down-gradient, the dynamo works automatically as a generator and charges the battery. When the vehicle is on an up-gradient, and the torque on the road wheels becomes greater than the turning moment of the engine, the speed of the latter diminishes and the voltage of the dynamo falls until it becomes less than that of the battery. The battery then discharges into the dynamo, and thus produces torque, which assists that of the engine until it balances the resisting torque of the engine. On a down-gradient, if the resisting couple is less than the turning moment of the engine, the speed of the latter tends to increase, and the voltage of the battery rises so that the dynamo begins to charge the battery. As this charging current passes through the regulator the rate of admission of mixture to the engine is reduced to a minimum, and the torque of the engine becomes zero.

*(To be continued).*

# THE EDISON BATTERY-DRIVEN TRUCK.

By R. Douglas-Vickers.

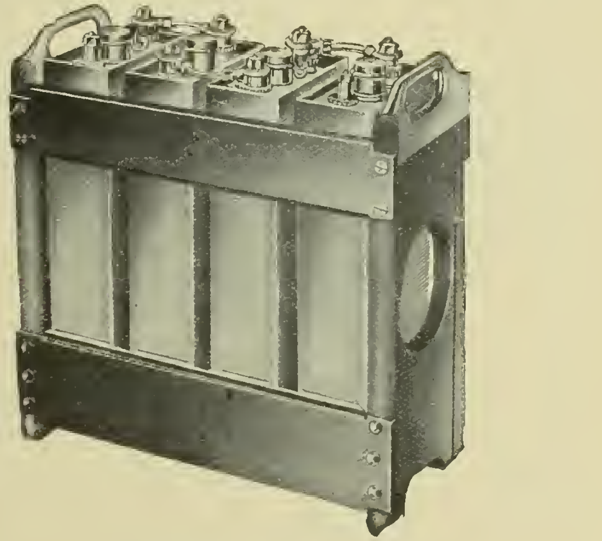
## The Edison.

Considerable interest was taken in the subject and in the announcement itself when, some years ago, Edison allowed it to become known that he was engaged in producing an electric storage cell which would not contain lead, celluloid, or sulphuric acid in its construction. Its principal features were to be light weight and small volume, qualities eminently desirable in anything for use on a road motor vehicle. The new accumulator was not to suffer from such defects as buckling plates, broken containers, sulphations, acid fumes and so forth, which had hitherto vexed the user of electrical apparatus of this kind. Subsequent events proved that the eminent inventor was as good as his word. The new outfit which bears his name has been described as real "bottled electricity," the accumulator retaining its charge almost indefinitely without leakage. In road transport service it gets probably the most severe test as to its various qualities that an accumulator could be expected to undergo, and it is only fair to say that the Edison has stood the test admirably.

## The Accumulator.

In this accumulator lead and sulphuric acid have been replaced by nickelled rolled sheet steel and a steel preserving solution of potassium hydrate. Lead, as readers of this journal know, is a metal of no great strength, whilst sulphuric acid is notable for its metal corroding quality. In the Edison accumulator the positive plates are an assemblage of unit tubes made from finely-perforated nickelled steel strip and filled with alternately-arranged thin layers of nickel hydroxide and fine metallic nickel flake. These tubes are surrounded by solid steel rings at equal distances apart. A complete positive plate is simply an assemblage of these unit tubes, a light punched nickelled steel frame serving as a mounting for them, their number depending on the type of cell for which the plates are intended. The negative plates are also a collection of small units, but of oblong pocket form instead of tubular. Iron oxide, to which is added a trace of mercury to make it conduct better, is enclosed in flat steel pockets, also made of nickelled steel strip finely perforated. Special care is taken to prevent their working loose through vibration.

When completely assembled, the Edison cell comprises a series of positive and negative plates insulated from each other and from their steel containing case. The steel ter-



The Edison Accumulator.

minal posts have transverse bolts passing through their lower ends, which serve to make contact with the plates and to keep them separated at the correct distance apart. Strips of rubber between the plates prevent any contact. The terminal posts project through insulated and liquid-proof stuffing glands mounted in the welded in top of the cell, which serve as a combined filler cap and gravity valve. The container is made of a particularly tough grade of nickelled cold-rolled sheet steel, welded by a special process at the seams. In order to give the container the maximum mechanical stiffness, the sides are corrugated. One of the claims made for this container is that no amount of vibration will fracture it, and from what I can learn, this is probably true enough if we consider only the vibration experienced in normal service. The other point affecting its durability is the absence of any deleterious action brought about by the long-continued action of the electrolyte. The case of the Edison accumulator is nickel-plated by a special process involving annealing in an atmosphere of hydrogen—a treatment which, it is stated, actually welds the thin coating of nickel on to the steel.

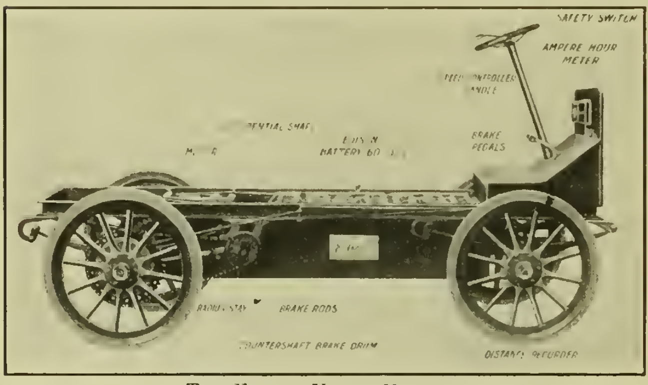
The electrolyte consists of a solution of potash in distilled water, with a small percentage of lithia. It is

important that nothing but clean distilled water should be used, so as to maintain the proper level of electrolyte.

The Edison accumulator gives, I believe, from 7·5 to 12 ampere-hours per pound of complete assembled battery. It has a considerable storage capacity, and, put in plain language, an accumulator weighing only 16 lbs. gives an output of one horse-power hour. An important feature claimed for this make of cell is that its efficiency does not appreciably fall off with use. Indeed, the contrary seems to be the case, strange as this may seem, whilst the capacity, both in ampere hours and in watt hours, appreciates with service. Records taken with various types have shown this to be the case.

## The Edison Motor Vehicle.

In regard to the commercial electric motor vehicle as a whole, there is much of it that is common to the ordinary




THE EDISON MOTOR VEHICLE.

vehicle. For example, the final drive, which may be bevel, chain, or worm. In most of the heavier types it will, I think, be found that chain transmission is usually employed, the motor driving the usual countershaft, which carries the differential. One Edison model W the drive is radically different to those named. It is provided with what is known as a patent balance drive. In this the power is delivered directly to the rims of the rear road wheels in a steady balanced manner from a single motor, which is located in the hollow rear axle. All parts are enclosed so that dirt is not likely to interfere with the mechanism, whilst an oil bath in the interior of the steel disc wheels ensures the gears working under ideal conditions. In the arrangement of the balance gear on this model we have two driving shafts extending from the differential sockets into the centre of each hollow rear road wheel, with a pinion on the wheel end of each shaft. In each of the rear wheels there are two idler gears, which drive the rim gears fastened to the inside of the tyre rims. An important point to be noted in connection with this electric is that no mechanical knowledge or experience is necessary to drive it. The control from rest to full speed is obtained merely through the movement of a small lever situated by the side of the driver, an operation so simple that it is quickly picked up.

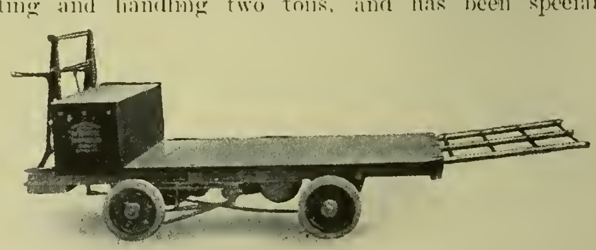
## Cost of Operation.

Much evidence is now forthcoming as to the cost of operating Edison electrics under a great diversity of service conditions, and I have no doubt that any textile company interested in the subject can have details from the makers, Messrs. Eddison Accumulators Ltd., 2 and 3, Duke Street, Piccadilly, London, S.W. The company commenced operations about three years or so ago, and their trucks may now be numbered by hundreds on the roads of the United Kingdom, although principally in and around the chief centres of population. Experience obtained with a 2-ton Edison in the service of the Liverpool Corporation shows it to have cost less than 8½d. per mile to run, a very reasonable figure indeed when we remember that short runs and many stoppages invariably characterise municipal transport. It is, however, to ordinary commercial operations that we look for the most typical service, and it is significant that these trucks are being utilised by so many commercial and manufacturing concerns, especially as, a few years ago, the general view was that the field of the electric would be constantly restricted to municipal service, where the municipality might desire to be its own customer, so to speak, for the necessary electric current.

## The Edison Indoor or Yard Truck.

Before concluding this notice of the Edison accumulator and its application to heavy haulage work, I would like to direct attention to the company's trucks for indoor or yard transport. The ordinary hand truck, like the horse truck, has its limitations, but with the advent of the heavy electric there has come the light electric for platform work at railway terminals, and more recently for factory work, where goods or raw materials have to be moved short distances. The Edison people are catering for this by their model "Automatic." Naturally, it costs very much more to buy than the old-fashioned truck, but the labour it saves more than counterbalances the first cost. Not only does it carry a load, but it will haul a train of trucks such as are found about railway depôts, quaysides, and warehouses. These light electrics, by reason of their short wheel base and narrow gauge, are particularly suitable for mills and factories where yarn, cloth, or other commodity has to be moved along passageways or from one department to another. Furthermore, almost any type of body—including even those of the tipping type—may be utilised, and the utmost dispatch observed in both loading and unloading.

A specially useful type of "Automatic" truck turned out by this company is type "L." It is a new gear-driven machine, fitted with an electric lifting device, capable of lifting and handling two tons, and has been specially



THE EDISON INDOOR OR YARD TRUCK.

developed for use in works where materials have hitherto been picked up and laid down unnecessarily. These trucks are provided with a special type of removable platform, which may be quite a rough and ready affair. The work is stacked upon this platform, and when a particular batch is finished, the electric vehicle comes along and drops a new platform for the next lot, subsequently moving under the filled platform, which it carries off to its destination. It may be mentioned that the floor of the truck can be depressed (to go under a loaded platform) and elevated (to carry it off) at will. In this way the truck is kept constantly at work with a minimum of attention, except to replace or charge the batteries when these are exhausted.

# BOILER-HOUSE EFFICIENCY.



*(Specially contributed.)*

*(Continued from page 232.)*

## Heat Transmission.

In all the water-tube boilers previously described, the water has passed through the tubes in a single unbroken stream, or as a mixture of steam and water.

In another group of boilers the stream is divided by the insertion of a second smaller tube into the main tube,

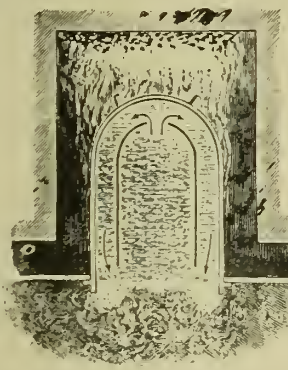


Fig. 93.—Boiler-House Efficiency.

and both the falling and the rising streams take place in these tubes.

As far back as 1831 Perkins found that by using an apparatus as illustrated in Fig. 93, in which a smaller tube, open at the top and bottom, is placed inside the larger tube, circulation is considerably increased. The heated water in between the two vessels rises and then descends through the centre vessel.

### Field Tube Boiler.

The best known application of the above principle is in the Field tube boiler, arranged as shown in

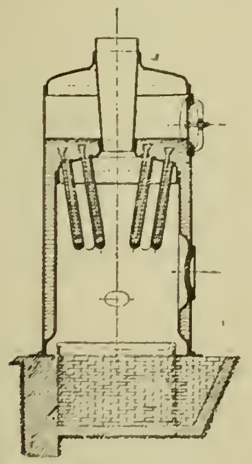


Fig. 94.—Boiler-House Efficiency.

Fig. 94. The water passes from the main chamber down the inner tube, being heated in its passage from the mixture in between the tubes. This heated water passes out of the inner tube into the lower end of the outer tube, and rises along with the generated steam in between the tubes. At the top the inner tube is shaped so as to guide the mixture rising from between the tubes away from the centre, and so prevent any disturbance which would hinder the passage of the feed water into the inner tube. Trouble, however, has been experienced by such interference, and the solution of the difficulty has been found in having separate chambers for the feed water into the inner tube, and for the mixture of water and steam from the space between the tubes.

Boilers arranged on the Field principle have been used by leading makers of fire-engines, as, owing to the rapid circulation obtained, steam could be raised very quickly.

### The Niclausse Water-tube Boiler.

The Field boiler above described is the prototype of the more modern Niclausse boiler, and it is most interesting to note that the highest combined boiler and economiser efficiency yet reported in well-authenticated tests is given by Captain Sankey in his report on test of a boiler of this type. The heating surface of the outer tubes of the boiler in question was 1,870 square feet, and of the economiser 1,285 square feet, making a total heating surface of 3,155 square feet. When working at 213 lbs. steam pressure,

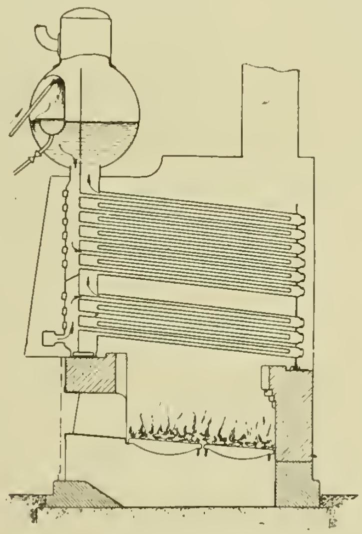


Fig. 95.—Boiler-House Efficiency.

evaporating 18,696 lbs. of water per hour from and at 212 deg. Fah., and burning 18·4 lbs. of coal per square foot of grate area, the thermal efficiency was 90·5 per cent.

Fig. 95 gives a section showing the arrangement of the latest type of boiler.

It will be seen that the boiler consists of slightly-inclined tubes free at the back end, and secured at the front end into a series of vertical headers, which in turn are fitted by coned joints into the common water and steam drum.

### The Common Water and Steam Drum.

Fig. 96 shows the water circulation and feed arrangements in this boiler in greater detail. The steam and water drums are divided into two compartments by a longitudinal diaphragm plate in prolongation of the vertical partitions in the headers, as shown in Fig. 95; the feed, after passing through a trough C wherein carbonates and other impurities are precipitated, and whence they are ejected by means of a blow-down valve D, enters at the front compartment, descends the vertical headers for a certain distance determined by a cross diaphragm E, passes into the upper evaporating tubes and returns with the

steam there produced into the back compartment of the drum, which consequently contains only hot and purified feed. In the modern land-type boiler there is no cross diaphragm fitted in the front compartment of every fourth or fifth header, so that this header serves to feed the "bottom box" M and the lower tubes of all the headers fitted with the cross diaphragm, whilst its own lower tubes are served direct. Referring to Fig. 96, the areas covered by small dots represent cold feed water, and it will be seen that from the headers A, which have the deflector plate E fitted in the front compartment, the feed passes into the top tubes, up into the back partition of the header, and from here down the front portion of the headers marked B into the "B" tubes and bottom box M. From this box the bottom tubes of the A headers are supplied with water.

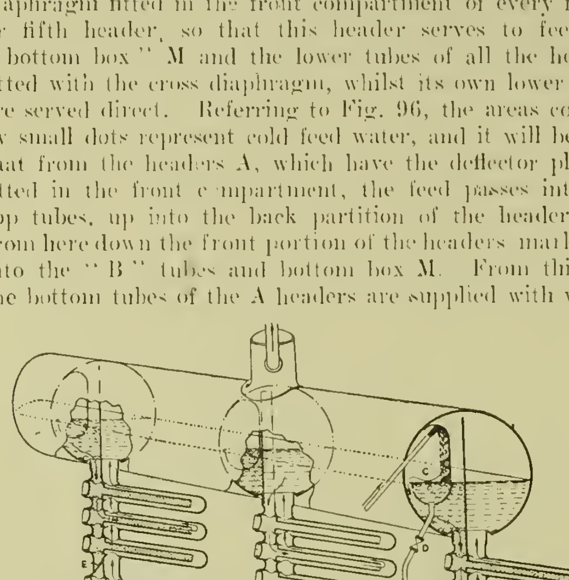



Fig. 96.—Boiler-House Efficiency.

It will be evident that with this arrangement the lower tubes which are most exposed to the heat of the furnace receive the feed at boiler steam temperature, and free from any impurities which can cause deposit. Any impurities in the feed to the upper tubes are practically harmless, since the temperature of the gases surrounding them is insufficient to form a hard scale.

Evident from the above description that the arrangement of the feed distribution is such as to ensure the maximum efficiency of the heating surface, and the circulation obtained throughout such as to make the boiler a rapid steamer and flexible in steam production.

As showing the flexibility of this type of boiler, the following rates of combustion were obtained during a five hours' trial with the boiler described above. Half an hour at the combustion rate of 19·5 lbs. of coal per square foot of grate area; half an hour at a combustion rate of 36·8 lbs; half an hour at 46 lbs.; one hour at a rate of 49·2 lbs.; a quarter of an hour at 36·8 lbs.; a quarter of an hour's stop; ten minutes at 19·5 lbs; three-quarters of an hour at 27·6 lbs. with oil fuel; and a quarter of an hour at 19·5 lbs. of coal per square foot of grate surface per hour.

*(To be continued.)*

At the annual meeting of the Manchester Association of Engineers Mr. Jos. Philips Bedson, of Messrs. Richard Johnson and Nephew, Bradford Ironworks, Manchester, was elected president for the ensuing year, and Messrs. H. H. Asbridge, S. Boswell, R. Onions, J. H. Widdowson, and F. Waltbew were elected to the Council.

# COAL AND ITS CONSUMPTION.

By W. H. Casmey.

(*Continued from page 237.*)

## Remedy.

To remedy the state of things indicated is not such a serious problem, but it certainly is one which has been most carelessly handled, each generation appearing to have been satisfied to follow in the footsteps of its predecessor. The present scarcity of coal, however, makes it now imperative for us to move and to let "the dead past bury its dead." Now what is the position? We have to produce heat for our various industrial purposes, and the method is to cause air and coal to chemically unite: but one thing is self-evident that there must be, and is, some exact proportion between the two elements to produce the maximum temperature, otherwise science would be a matter of mere guesswork. Does a chemist in the dyeworks mix carelessly the various ingredients when a given shade of colour is required? No; he very carefully weighs each item and knows what his result will be every time and the same rule applies in every industry, and until we produce method in the boiler-house waste will continue.

We know that air is composed of two principal gases, oxygen and nitrogen, the respective proportions being one to four. To burn one pound of carbon, the chief element in coal, 12 lbs. of air, or 150 cubic feet, are needed, the resulting temperature being a little over 5,000 deg., and this temperature is constant under all and every condition, and is one of the facts engineers should very carefully keep in mind. Our ordinary steam coal contains from 70 per cent to 75 per cent of carbon, the remainder being gaseous products termed hydrocarbons, and to burn 1 lb. of such coal so as to secure the best practical results 15 lbs. of air, say 200 cubic feet, are required, and this mixture gives a furnace temperature of 2,500 deg.

When coal is burned the oxygen and carbon unite and form carbon dioxide, or $CO_2$, and the percentage of this gas in the products of combustion is the means of detecting the percentage of air supplied to the fire. With 15 per cent of $CO_2$ the proportion of air to coal is 15 to 1, with 9½ per cent $CO_2$ the proportion is 25 to 1, and from the percentage of $CO_2$ and the calorific value of the coal the furnace temperature can be calculated.

If the chemists in dyeworks, steelworks, etc., can secure the same results every time, why not the stoker? Simply because little has been done in producing the required instruments to enable him to know the proportion of air and coal he is feeding to his boilers. We are well aware the $CO_2$ recorder has done something to assist in this direction, but is far from being a popular machine, but an instrument recently patented will, if all its claims are substantiated in practice, come nearer what is required.

## A Combustion Indicator.

I have received the following notes from the patentee and inventor of this apparatus:—

"I have pleasure in announcing that the combustion indicator mentioned recently to you has been in successful operation for the last eight weeks. The many difficulties you mentioned that previous inventors had met with I have not encountered. This is, I believe, because I have not followed on their beaten track. Filtration has caused no difficulty whatever. A brief description of the principle of this indicator will probably explain its successful working. The instrument consists of a porous vessel, around which the filtered flue gases circulate, due to the agency of a small

steam ejector, or other means. Inside the vessel is a cartridge containing a dry absorbent for $CO_2$. The action of the instrument is thus: Any $CO_2$ which diffuses through the pores of the vessel is immediately absorbed, and a vacuum being produced, which is exactly proportional to the quality of $CO_2$ in the flue gases. To measure this vacuum a water column is used, and it is found 10 per cent of $CO_2$ is shown by 10 inches of coloured liquid in the $\frac{3}{4}$ in. diameter glass, which can be seen 20 yards off. The advantages of this instrument are: (1) The great simplicity, consisting of no moving parts whatever; (2) a continuous reading on a large scale is obtained. All the stokers can thus see what is taking place at a good distance away; (3) unlike other $CO_2$ recorders, only show what has taken place, and are thus of little use to the stoker. This instrument shows what is occurring at any instant, and will immediately detect the presence of a hole in the fire; (4) the absorbent is dry and inside a cartridge; (5) no rubber-piping or corks, glass bottles, or tubes, floats, pulleys, and chains, three-way cocks, bad valves, syphons, or gas meters, burettes, or sloppy absorbents (attacking everything near) are of any use on this new indicator, which is made entirely of brass and copper in air-tight metal box with glass front; (6) the only attention that is required is the renewal of the cartridge occasionally. Owing to the great difficulty in getting the instruments made, I have been unable to forward you one, as promised, but will do so in the near future."

## Air and Coal.

We found with a mixture of 15 lbs. of air to 1 lb. of coal the temperature was 2,500 deg., but as in general practice 25 lbs. to 30 lbs. of air per pound of coal are supplied, and although the temperature of combustion is the same as in the previous case, the excess air reduces the furnace temperature down to 1,800 deg. The old expression, "We cannot have both toffee and penny" illustrates this point, as we cannot have the heat for raising the temperature of the 10 lbs. of excess air from 32 deg. to 1,800 deg. from every pound of coal burned, and use it for raising steam as well, and this waste heat represents one-tenth of the calorific value of the fuel.

With 15 lbs. of air per pound of coal, the loss through excess air is only 4 per cent. With 20 lbs. of air it increases to 7 per cent; with 25 lbs. of air, 12 per cent; and with 30 lbs. of air the loss is a little over 15 per cent, the difference in temperature between the two extreme points being 1,350 deg.

The rates of radiation between two furnaces, one fed with a ratio of coal and air 1 to 15, and the other 1 to 30, is as 3 is to 1. In other words, one square foot of fire surface, when fed with air and coal at a ratio of 15 to 1, does as much work as three feet of fire surface with a ratio of 30 to 1; or, if the air supply was 25 lbs., three square feet of grate would only be equal to two square feet with a ratio of 15 to 1.

## A Two Boiler Example.

Now assume we have two boilers side by side, one with a grate 6 ft. long, and having an air supply of 25 lbs. of air per pound of coal, the other boiler grate 4 ft. long, an air and coal supply of 15 to 1, the latter boiler would give the same evaporation as the other, but in doing so would consume over 10 per cent less coal, the heat being taken up the boiler, not wasted on the excess air. From what has been advanced, we know that if our boiler grates of 6 ft. long were reduced to 4 ft., and the proportion of air and coal as given followed, we should secure the same evaporation, but for less fuel, and the natural question therefore is, if 6 ft. grates were worked on the same basis, would not the evaporation be increased and the higher efficiency be maintained?

Neither efficiency nor evaporation could be maintained, and for the following reasons: A grate 6 ft. long cannot be worked as efficiently as a shorter grate, excess air filtering through the bar spaces, due to their not being so well covered as on the shorter fire, but even were this difficulty overcome, there is the more important one of draught, and this is governed by the sectional area of the furnace flues at the downtake. Assuming the chimney draught is constant, the volume of gas taken from any boiler will be governed by the area of the furnace flues at the rear, and to get a constant furnace duty the proportion between grate area and the sectional area at the rear of the flues must always be constant. This is a point, however, which never appears to have been considered, therefore we find to-day a 7 ft. diameter boiler has four square feet of grate to one square foot of outlet from the flues; an 8 ft. diameter boiler has $3\frac{1}{2}$ square feet of grate; an 8 ft. 6 in. diameter boiler three square feet of grate; and a boiler 9 ft. in diameter has $2\frac{3}{4}$ square feet of grate per foot of outlet. Therefore, in a 9 ft. diameter boiler, $2\frac{3}{4}$ square feet will do the same work as four square feet in a 7 ft. diameter boiler. Which of these proportions, if any, can be taken as correct?

## The Best Results.

In practical experience we have found the best results, both in duty and efficiency when the proportion between grate and outlet is in the region of 2 to 1; hence, by reducing a 6 ft. grate to 4 ft. or 4 ft. 6in., the better results are secured. To arrive at a suitable grate area for any size boiler, multiply the sectional area of the outlet at the end of the flues by two, and as an illustration, this area in a 9 ft. diameter boiler is 16 square feet. The suitable grate, therefore, for this boiler is 32 square feet, say 4 ft. 6 in. long and 3 ft. 8 in. wide; but in a 7 ft. diameter boiler the area of the flue outlet is eight square feet. This multiplied by two gives a grate area of 16 square feet. It should therefore be not more than three feet long. It was this lack of uniformity referred to in the Lancashire boiler which brought the Yorkshire boiler to light, and one reason for its success is to be found in this fact: that in all sizes of boilers grate area and outlet are constant; therefore the results can be anticipated with certainty.

## An Illustration.

As an illustration, a 9 ft. diameter Yorkshire boiler has a sectional flue area of 22 square feet, and the ratio of grate to outlet is 1·8 to 1, which, multiplied by 22, gives a grate area of 39·6 square feet; therefore 6 ft. long and 3 ft. 3 in. wide; and in a case of 7 ft. diameter boiler, the outlet is 12 square feet, grate area 22, namely, 5 ft. long and 2 ft. 2 in. wide. Sufficient has been said to clearly indicate the key to any boiler is its furnaces, and the power to use such key the available draught, and that with a right proportion of air and fuel, other things being equal, black smoke is an impossibility. The points for any boiler man to aim for are the highest possible initial temperature and the lowest terminal temperature, and it is the greatest amount of heat absorbed between those two points which we require.

## Efficiency and Evaporation.

We are now in a position to measure up the boiler, and give a reliable figure as to what its possibilities are, both

from an efficiency and evaporation point of view, and the size of grates being settled, we may now turn to the question of how best to handle them.

Assume our typical boiler is 9 ft. diameter, and we have reduced its grates from 44 square feet to 32, the air space between the bars is reduced from 11 ft. to 8 ft.; and assuming the draught at the end of the furnace flues 1,000 ft. per minute, this indicates nearly 16,000 cubic feet of gas per minute passing this point, or a velocity through the air spaces of the furnaces of 600 ft. per minute, as against 450 ft. with the longer grates. It is therefore possible to work with brick fires, with the resulting higher temperature and increased evaporation per pound of coal burned. When fresh coal is added to a fire, the first effect is to cool it, and as a given temperature is required to ignite the excaping gases, the necessary air supply for combustion should be heated, and the possibility of black smoke thus prevented. To attain the required conditions the fireman should stoke on one side of his fire at a time, and stoke from front to rear, not using more than three or four shovelfuls at a time. By this method a brilliant white fire would be maintained. The time for stoking should not be regulated by the steam-gauge, but by the attendant's good sense; that is, the man must stoke with his head as well as his shovel, and the coals used should be kept as dry as possible, as wet coals are a source of waste; in fact, 1 per cent of water means very nearly 1 per cent wasted fuel.

A brilliant white fire has a temperature of about 2,500 deg. Fah.; when the res have a yellowish tint the temperature is 2,000 deg., bright red 1,650 deg., and a dull red from 1,000 deg. to 1,200 deg. If, then, the fires are allowed to burn down to 1,200 deg., and are then stoked, black smoke is an absolute certainty.

*(To be continued.)*

# FACTORIES: THE BUILDING AND ORGANISATION OF THEM.*

By H. O. Blackford.

We have the fortune or misfortune to live in a time when events which have far-reaching results are moving over our heads very rapidly. In such a time it is hard to form a correct judgment in which direction the future will lie, and yet harder still to work out any future policy which affects our trade in the direction required. As no doubt most of you are aware, the future as far as the motor industry is concerned, lies, first, in the holding of the market which we possessed before the war commenced, and, secondly, the opening out of totally new fields of trade, which indirectly the war has brought about.

## Are our Factories Suitably Built and Staffed?

To-night it is my intention to open out a debate on: Are our factories suitably built, and staffed, for the immense trade war and competition which most people predict will follow directly on the heels of peace? This subject has been spoken upon many times of late, and various are the suggestions made to improve and prepare the way. But few seem to get to the very bottom of the matter.

The present needs are, of course, to push ahead and get this war over. And really, if an example on a large scale of forewarned is more than forearmed is wanted, then we have not far to look for it. It is the detail, and the organisation of it, which counts when anything on an immense scale is undertaken. It has been pointed out recently to us what can be done if gone about in a proper manner, with due regard to future needs, so often forgotten. Even in such a supposed simple matter as directing and organising, much has to be learnt by hard experience, and much useless ground has to be covered before results are shown, these being my reasons that a start should be made at once.

## Placing and Planning a Motor Factory.

With these introductory remarks, I will proceed with what I have to say.

We will first take the placing of a motor-car factory, and the planning of the buildings, speaking of the average in the British Isles to-day. Before going inside, the general outline strikes one as a mere jumble of buildings, one added to the other in a very haphazard way. Which if one happens to be in the trade, it crosses the mind that a successful chassis (perhaps at the show) has put the works at a sudden great pressure. The result of the want of forethought on the moment, being put up in the indisputable evidence of the building. If the limit of land in one certain direction has been reached, then without any apparent (certainly no practical) forethought, the new building is erected in the direction of least resistance, if I may put it before you in that way, no regard at all being paid as to how that will affect the unnecessary handling of the part or parts of the chassis the shop is being put up to manufacture, or to the complete smooth running of the works. It is the absolutely needless, and useless, conveying of parts from one end of the factory to the other, for no other reason but the next process of manufacture the part is to be put through, that brings a simple problem to a very difficult one. And, certainly, if the factory as a whole is not planned to suit, then with such a foundation to work on, nothing more or less than failure to advance in output can be expected. It simply clogs the organisation, and stifles it if the place is in no way suited for its job. And before an output of large dimensions can be expected, it must be from a factory of modern ideas, especially with such highly skilled and detailed work as motor-car manufacture. Merely as an example, I have seen a large and hefty component of the car having to be moved, singly, from one end of the factory to the other, simply for its next operation. You will no doubt say this is against all the rules of common-sense, let alone organisation, but the surprising part of the business is that such things exist even to-day. The whole business of needless handling of parts becomes deeper and deeper as one goes into it, and more thought has to be expended for certain to obtain anything like order on a large scale than most people will admit. If parts have to be moved through various departments to reach their destination, then in passing on their way, it is needless to remark, they cause a diversion. The labour, totally unnecessary, always has been a source of wonder to me why that alone did not tell those responsible that something could be done to obviate it. And in the future it must be done, because labour in whatever direction one may take will have to be used to its best advantage, with as little waste as brains will allow.

## Good Planning Requisite.

To my mind, in the planning out of a works, just as much thought is required to get a place which approaches

* Paper read before the London Graduates of the Institution of Automobile Engineers.

anything near the ideal as the designing of the chassis, and in the future it will be just as important, although few seem to realise it. I believe that is because all the attention has been devoted to the betterment of the chassis all round, with the splendid results we see to-day. The past, perhaps, did not matter quite so much, because the vast improvements obtained year by year gave standardisation on a large scale but small room to grow. Also the fact our designers started some eight or more years late to Continental firms. But commercially, they have to hurry up, and soon; a lost start there would perhaps be harder to pick up. By this I do not want you to think I have in my mind perfection is reached regarding inventions and trend of design, that I cannot say. But it is my earnest conviction the time is at hand when cars will have to be turned out cheaper. By cheapness I do not mean the American ideal, but cheaper because of vast improvements in general factory placing and control. It can be done, without a doubt, and unless we are prepared to hand over our trade to others (who, by the way, are only waiting), it will have to be an accomplished fact.

The line taken up when building a factory in pre-war days was to give the contractors a general outline as to what was required, and then leave the most important part, the detail, in their hands. The said firm may be excellent people in putting a building up, but can have no idea what is best suited for the job. If you have had experience enough, and are able to adapt it, which is no easy matter, the shop should be for that particular job only, and not a chassis test, body shop and paint shop, all within a very few years, as the so-called improvements proceed in the factory. As things are done to-day, they are nothing more or less than makeshifts, totally unsuitable in the way they fall in with the rest of the factory, which in the long run is surely a waste of time and money.

### Mapping out the Works.

Now, what I have to suggest is this: Speaking very broadly, and not pretending to go into detail at all, as a paper could be written on each separate department, its design and equipment. A works should be mapped out with the shops each carefully designed for its individual requirements, such requirements being found out by experience only and could not be enumerated off-hand, as far as it is found practicable to do so, and with a keen eye to its future extension. The arrangement with its immediate neighbours should be such that a minimum amount of labour is required to move the parts under operation from the one department to the other, and they should be in correct sequence one to the other.

I believe more use should be made of two or three-storey buildings, the top storeys of which should be set aside for the lighter components. The advantage is, a factory can be kept compact, and heating and lighting and all detail made an easier matter to fix up, also lifts, which are great labour savers, could be extensively used, and they would allow the parts to be moved rapidly and without commotion. These lifts should be connected by passages which are outside the shop itself.

### American Methods.

It has not been my fortune to travel in America, and although I hold no brief for their ideas of a real good car, their way of tackling output on a large scale contains many common-sense ideals. What I have read and heard of their methods, they are the right ones for the particular job, and little or no time is wasted anywhere. Up to the present, the American car and American practice has been the object of cheap jokes here, often uttered by people who will find later on the old proverb, "He laughs best who laughs last," a very true one. There is no business method in making the attempts of a rival for your trade a place to exercise your wit. Rather live and learn, and respect, at any rate, one who has immense business methods behind him, even if his article is inferior to yours. Many English managers have crossed over to study their ways of production, but, so far as I can see, the only place to receive any benefit is the machine shop. Of course, I know what one reads and hears is often enough far from the truth, but figures speak for themselves, and when the home market on the other side of the Atlantic is near the point of saturation, then such a people would not sit and bemoan their fate, but would be inclined to seek and make a bid for what they wish to get. I do not think for a moment they have had a serious try at it yet, and if only we have the means in the shape of properly planned and organised factories, then the price of the car, being much nearer what it should be, the British public will do the rest.

After all, it rests with the people who buy, and not those who sell, who shall come out on top. And "The Article," in whatever line you take, usually sells itself. If there is a large "if" in a particular chassis, the buying public get to know as soon as anyone, and it is not easily passed over if the car is of a large initial cost.

### Offices and Works.

But to continue on the state of our present factories. It is often found, even in the very latest ones built, that more attention has been given to the elaboration of offices and entrances than to the vital spot, the inside where the work has to be produced. And one could point out some glaring examples of offices, etc., quite what they should be, but the inside nothing more or less than chaos, to sum it up.

*(To be continued.)*

## LIFTS, TRANSPORTERS, AND CRANES.

[Messrs. William Wadsworth and Sons Ltd., Bolton.]

Apropos of recent articles which have appeared in textile journals dealing with the electrification of mills, there is one important phase of this industry which has not been previously dealt with, viz., lifts, transporters, and cranes.

It must be admitted that quick production cannot be achieved unless there is expeditious handling of material, and it is surprising in so-called modern mills what antiquated methods are in vogue for lifting and conveying material.

The substitution of electrical and mechanical transport for hand labour is quite a matter of necessity where heavy weights have to be taken from one end of the factory to another, and such appliances as lifts and transporters are of incalculable value; they reduce labour, economise time, and consequently save money.

It is somewhat incongruous to see firms producing yarns with twentieth century machinery, and at the same time handling both the raw and finished article in eighteenth century fashion.

The utilisation of electricity enables a lift or transporter to be run independently of the engine, and this is very desirous where lorries have to be loaded or unloaded during meal hours or after working hours. Quite 95 per cent

of lifts are driven from shafting in the top storey, and should this be stopped, the lift, of course, is out of commission. A lift direct coupled, or belt-driven from the motor, can be put into service at all times. Fig. 1 shows a motor belt-driven lift by Messrs. Wadsworth, of Bolton.

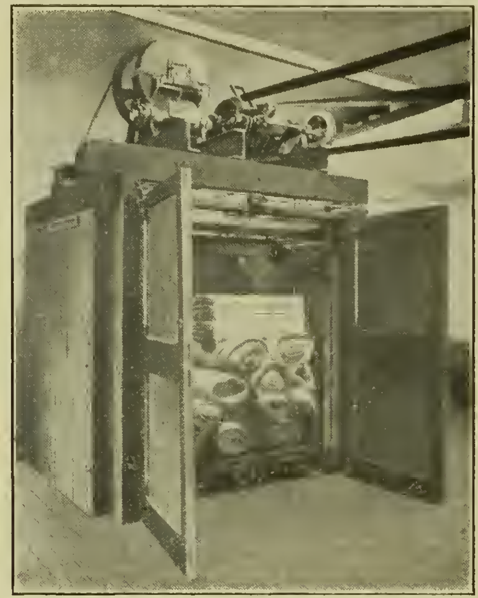


Fig. 1.—Belt-driven Lift.

The common argument against the installation of electric lifts in mills is that, as long as shafting is handy and power available, why not use it? Wherever the power is taken from, it has to be paid for, whether through the main engine and shafting, generator, or supply company, and the advantage of an independent lift or hoist is not to be under-estimated. Further, electric lifts can be run at much quicker speeds than belt-driven lifts; they can also be fitted with more reliable safety appliances, and, as regards the cost of running, an electric lift is extremely economical. Many firms will not entertain the installation of electric lifts on account of not having their own electrician. Of course, where electricity is generated on the site this does not apply, but where the supply is obtained elsewhere this need not be a deterring factor, as an electric lift from a first-class maker is thoroughly reliable. Further, inspection and maintenance contracts can be entered into with either the insurance company or the lift makers. Fig. 2 shows the type of transporter installed by the above-named firm.

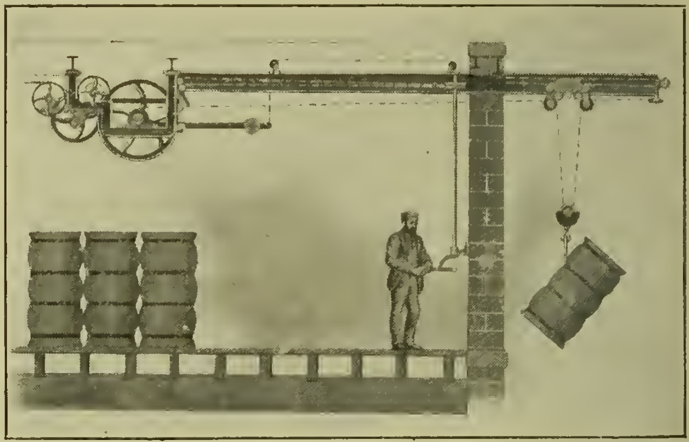


Fig. 2.—Transporter.

Fig. 3. Electric Lift.

A lift with patent control has recently been put on the market, which has met with great success. The arrangement consists of a belt-driven lift (Fig. 3), which, of course, can be driven either from a countershaft or from a motor, and the operation is by a switch in the car. The device is so simple that any average mechanic—even without electrical knowledge—can attend to same. In many cases where these lifts have been installed, or existing lifts fitted with this patent control, men operators have been dispensed with, and girls are utilised for working the lifts.

Many leading firms are now converting their lifts to direct electric drive, and it is quite evident that the ordinary type of belt-driven lift will soon become obsolete.

A summary of the chief advantages of an electric lift is: Quicker speed, increased security against accidents, economical working, simplicity of control.

Readers desirous of full information and advice can have same by applying to specialists in this branch of work, namely, William Wadsworth and Sons Ltd., Thynne Street, Bolton.

## THE PERFECTA BOILER CIRCULATOR.

[The Perfecta Boiler Circulator Ltd., 39, Victoria Street, London, S.W.]

Engineers and owners of steam boilers are fully alive to the advantages and importance of securing perfect water circulation in boilers. The "Perfecta" Circulator (herewith illustrated) is an apparatus which has proved to be a most simple, practical, and economical solution of a problem which has engaged the close attention of engineers and boilermakers for many years. The method by which the "Perfecta" Circulator operates will be readily understood by reference to the accompanying illustration. It is

automatic in action and consists of a hood or covering over the crowns of the furnaces. The steam bubbles that are generated by the furnaces rise in a vertical direction and, bursting under the circulator, create a flow of water towards the back of the boiler, where it takes a downward direction and returns along the bottom of the boiler to the furnaces. This motion is very rapid, and produces perfect circulation, and by bringing the whole of the water continuously in contact with the hottest parts of the boiler, causes a great increase in the temperature, the steaming capacity is thus increased and a more uniform temperature obtained. The constant flow of water, set up by the circulator, causes all sediment and foreign matter to settle in the vicinity of the blow-down cock, which, being opened once or twice a day, discharges these, thus maintaining a clean boiler. As a result of this perfect circulation the unequal expansion of the plates and consequent strains are claimed to be entirely overcome. In preventing the steam bubbles rising immediately to the surface of the water, priming is eliminated and a regular supply of steam is obtained with a greatly decreased saturation.

It is important to note that the installing of the "Perfecta" Circulator does not necessitate the drilling of any holes in the boiler, or the interference with any existing fittings.

The makers claim that the "Perfecta" Circulator will

The Perfecta Boiler Circulator.

raise steam in half the time; give 12 to 15 per cent. increased steam which will contain a minimum of saturation; extend the life of the boiler by causing equalisation of temperature and expansion; prevent priming, and therefore maintain a regular supply of dry steam; prevent the formation of scale by keeping solid matter continuously in circulation; stop pitting and grooving by sweeping away all bubbles as soon as formed; prevent the seams from leaking by eliminating unequal expansion save the cost of constantly cleaning and scaling boiler, and reduce wear and tear; and minimise the necessity for water-softening fluids and plants.

The "Perfecta" Circulator, it is claimed, pays for itself in a few months, and effects a minimum annual saving of from £40 to £60 per annum in fuel (according to price). The saving in fuel is from 6 per cent to 8 per cent. The circulator is constructed of sufficient strength to last the life of the boiler. The latter can be freely inspected without removal of the circulator, but the whole apparatus can be dismantled in a few minutes. This is a special feature, and one that appeals to insurance companies. The "Perfecta" Circulator has been specially designed to meet these requirements. Practical demonstrations with model boilers under steam, showing the "Perfecta" Circulator in actual operation will be given at any time upon application to the company.

## WORKS PRACTICE IN THE METAL INDUSTRY: THE IMPORTANCE OF THE FUEL QUESTION.

At the annual meeting of the Institute of Metals, which took place on March 22nd, at Burlington House, Piccadilly, London, the members present were asked to give their consideration to four most interesting papers dealing with various aspects of metal melting, and special reference to the type of fuel used in the process.

Mr. George Bernard Brook, lecturer in Non-ferrous Metallurgy in the University of Sheffield, began his paper on "Coal-gas as a Fuel for Melting Non-ferrous Alloys," by stating that gas had always seemed to him the ideal fuel for such purposes. He then proceeded to give particulars of a test undertaken by him, on a large scale and closely following commercial practice, in order to provide reliable data upon which manufacturers could work. From the results of this test the main advantages of coal-gas as a fuel may be summarised as follows:—

1. The absence of dirt and accumulated ashes.
2. The elimination of the difficult and wasteful process of "slagging."
3. Economy in fuel.
4. Convenience.
5. Considerably smaller loss of metal than with solid-fuel furnaces.
6. Reduction in actual fuel costs.
7. Higher speed of melting, ensuring greater output.
8. Superior mechanical qualities of the metal.
9. Reduction of oxidation to the minimum.

Mr. Brook was followed by Mr. C. M. Walter, B.Sc., of Birmingham, who discussed in detail "Metal Melting by means of High-pressure Gas,"* and laid special stress on the point of metal losses, which, he said, should receive full consideration in any comparison of the relative melting efficiencies of various types of furnace plant. He pointed out that very considerable economies had been obtained in the melting of brass with gas-heated furnaces, the regulation of the temperature of which is under complete control, whilst the atmosphere in contact with the surface of the metal is non-oxidising, and any metal spilt over the side of the pot is directly recoverable by the removal of the bottom plate from the furnace; and he gave it as his opinion that the economies effected owing to the reduction of metal losses alone where high-pressure gas furnaces are employed, as compared with solid fuel furnaces, more than outweighs the extra fuel cost involved.

The third paper, by Mr. W. J. Hocking, dealt with "Metal Melting as Practised at the Royal Mint,"* and gave, among other interesting details, the results of a protracted series of experiments, made with various classes of fuels and burners, which proved that the most satisfactory results as to speed by melting and economy of cost were obtained by the use of coal-gas at low pressure. Mr. Hocking stated that comparative records kept over two periods of five consecutive years, during the latter of which (when gas was used) nearly 10,000 tons of metal were melted and cast into bars for coinage, show an economy in favour of gaseous fuel under each of the following heads: Output (the increase per furnace varying from 88·5 per cent to 161·1 per cent with different metals); fuel expenditure (a 3½ per cent cash

* Full reports of these papers will appear in subsequent issues —Ed. *I.E.*

saving effected with gas); cost of graphite goods (a 32·6 per cent reduction effected with gas); and cost of labour (a 20 per cent reduction).

Mr. H. M. Thornton, M.I.Mech.E., and Mr. Harold Hartley, M.Sc., jointly presented the concluding paper on "The Melting of Brass and Copper in a Crucible Furnace with Coal-gas Fuel,"* and gave figures to prove that the thermal efficiency of the gas furnace is about five times that of the average solid fuel furnace. In regard to the life of pots, they stated that: "In a gas-fired furnace the abrasive action of the solid fuel is eliminated, the direction of flow of the gas stream is under better control, the sulphur content of the fuel is very small, there is no fire to poke, and clinkers have not to be removed from the outside of the pot, so that it is not surprising that long lives can be obtained. . . . We should expect a 50 per cent increase in the pot life when a gas-fired furnace is substituted for one coke-fired." They also hold that "to claim a saving of time for melting of 25 per cent with a gas-fired furnace, against ordinary practice with a solid-fuel furnace, in the melting of brass would not be excessive."

Lack of space necessarily makes these extracts inadequate, but they nevertheless go to show that the gas furnace has come to stay and is bound to have a tremendous influence on our industrial prosperity after the war; for it is by no means in the metal industry alone that its superior qualities are ousting the old-fashioned solid fuel variety.

## THE NEW ELECTRIC POWER STATION AT BIRCHILLS, WALSALL.*

By Ernest Matthew Lacey, M.Inst.C.E.

The early history of the electricity undertaking of the Walsall Corporation and the original system of generation and transmission are briefly described: also the steps taken by the Corporation since the year 1913 to provide for an efficient supply of electricity in the Walsall area.

The conditions determining the size and site of the new power station are stated, and the question of possible land subsidence owing to old colliery workings is dealt with.

Reference is made to the controversies regarding the economy which arises in the production and distribution of electricity by the concentration of plant in power stations of large capacity, and the author expresses his views as to the ultimate limit beyond which no appreciable advantages would accrue by reason of such concentration. It is claimed that the Walsall power station is by far the lowest in cost per kilowatt of any yet erected in this country, due to special features in the design and type of plant installed, these special features consisting more particularly in the arrangement of the coal-handling and boiler-house plant.

The general arrangement of the coal-handling plant is fully described, the main object in the design being to obtain adequate coal storage and at the same time to save the heavy expenditure on constructional work necessary to provide for overhead coal-storage bunkers of large capacity.

The boiler-house is designed for six self-contained units, each unit consisting of a water-tube boiler with integral superheater, a superimposed economiser, ejector, induced draught plant, a steel "Venturi" type chimney, and a mechanical chain-grate stoker. Each unit is designed for a high duty evaporation of 30,000 lbs. of steam per hour from water entering the economiser at a temperature of 100 deg. Fah. In Appendix I. particulars are given of the normal and high duty tests of a boiler unit of the type adopted, the results showing an over-all efficiency of over 88 per cent based on the net calorific value of the coal. It is claimed that the Walsall power station is one of the first examples erected in this country for the accommodation of the special type of boiler unit described, and the more important features and advantages of the design are referred to.

A high concentration of steam-raising plant in modern power-houses is advocated, and the important bearing which it has upon the general and structural design of modern power houses and its advantages are fully dealt with, as is also the design of boiler necessary to obtain such high concentration.

The engine-house is designed to accommodate three 4,000-kw. turbine-driven alternators, of which two have been erected. The turbines are of the compound horizontal impulse type, and work with steam at a pressure of 180 lbs. per square inch and a temperature ranging from saturation to 620 deg. Fah. at the stop valve, the normal speed being 3,000 revolutions per minute. The construction of the turbines is described and attention is drawn to special features, more particularly to the provision of directing boxes for the control of the various oil and water pumps which, although the rule for marine work, have been but little used on land. The condensers are of the surface type, with rotary kinetic air pumps and centrifugal water-circulating pumps driven by electric motors. The arrangement is fully described, as also are the various appliances for measuring and recording the steam consumption of the turbines. The alternators are of the revolving-field type and generate three-phase alternating current at a pressure of 6,600 volts between phases, with a frequency of 50 cycles per minute, the full-load output of each alternator being 5,000 kilovolt-amperes. The more important features in the construction of the alternators are described, as also is the system of ventilation which has been applied and which, it is claimed, has special advantages. The extra high-tension switch gear is fully described, and the special features in its design and construction are referred to. The actual cost of the works under the various contracts is set forth, the figures showing that the cost of a 12-000-kw. station of the design described, at 1914 prices, is approximately £5 3s. per kilovolt-ampere of plant installed, or £6 12s. per kilowatt ($\cos\phi = 0·8$).

It is claimed that the economy of the Walsall design represents not less than 30 per cent to 40 per cent, and that not only has this economy been obtained without any sacrifice of efficiency for the sake of cheapness, but this type of station is in fact far more economical in operation than stations of more usual design.

The cost of producing electricity at a station of this type is fully dealt with, and curves showing these costs and the effect of the load factor thereon have been prepared. An appendix shows in detail the total annual costs of production and costs per kw.-hour sent out with a station load factor of 30 per cent. The system of transmission and distribution to consumers is briefly referred to.

* Abstract of paper read before the Institution of Civil Engineers, on Tuesday, March 20, 1917.

# BOILER-HOUSE OPERATION AND MAINTENANCE.*

By T. G. Otley and Verney Pickles.

It is not the intention of the authors of this paper to describe the plant of the power stations of the Rand Power Companies in any great detail, but to set out the methods of boiler operation and maintenance adopted and the efficiencies obtained, and it will only be with that object in mind that any description of the plant will be given.

## Brakpan Power Station.

The first power station was built at Brakpan, and as it was intended to contain only 2,000 to 3,000 kw. sets, and as there was only a limited space on which to build it, a parallel boiler-house design was unfortunately adopted, eight boilers being installed in a double row of four. The station was extended in 1914-1915 by the addition of two 12,500 kw. turbine generators, steam being provided by 10 additional boilers, also placed in a double row parallel with the turbine-house.

## Simmerpan Station.

On the other hand, the Simmerpan Station, designed at the same time to contain four 3,000 kw. sets, was provided with two boiler-houses at right angles to the turbine-house, each boiler-house containing eight boilers. This station was subsequently increased by the addition of two further 3,000 kw. turbine generators, the steam generating plant not being increased, as it was found that the existing boilers were rated on a very conservative basis. The station was again extended in 1914 by the addition of two 12,000 kw. turbine generators and another boiler-house added containing eight larger boilers. The first installation had four boilers to supply steam to one 3,000 kw. machine, whereas for the last extension four boilers provide steam for a 12,000 kw. machine. As at present arranged, the steam distribution is not too good, and results in excessive pressure drop between boilers and the two large turbines.

## Rosherville Power Station.

The next station to be built was that at Rosherville, which was designed on the same lines as Simmerpan, except that the five turbine generators are all of 9,600 kw. capacity and four steam turbines driving air compressors each of 4,000 H.P. capacity formed part of the equipment. Three boiler-houses were built, each containing eight boilers at right angles to the turbine-house. At this station the boilers were not designed on the liberal lines of those first supplied for Brakpan and Simmerpan, and when two further 4,000 H.P. compressors were installed it was found advisable to install eight more boilers in a fourth boiler-house. At a later date (1914-1915) three additional steam turbine compressors, each of 10,000 H.P., were added, necessitating a fifth boiler-house containing eight boilers of a larger size.

## Vereeniging Power Station.

Before the Rosherville Station was extended it was found necessary to build a power station at Vereeniging, 36 miles due south of Johannesburg, on the Vaal River. The Vereeniging Station contains two 9,600 kw. and two 12,000 kw. turbine generators. The four turbines are of exactly the same dimensions, but the electric generators for Nos. 3 and 4 machines are of larger capacity, the turbines having slightly different blading arrangements to enable them to pass more steam. The condensers also are larger. Steam is provided by 20 boilers erected in two boiler-houses at right angles to the turbine-house, the boilers being in rows of five.

Although local conditions must always affect design, there can be no question that for large power stations the boiler-houses should be built at right angles to the turbine house. With the constantly increasing size of turbine units and with the size of boiler units at present in use, any other arrangement is practically impossible. With turbine units of, say, 10,000 kw. to 12,000 kw., the kilowatt of turbine plant installed is in the region of 280 per foot run of turbine-house, whereas with boiler units of about 6,000 square feet heating surface the kilowatt installed per foot run is in the order of 80 to 90. The length and areas of turbine and boiler-houses in relation to the installed capacity of the plant at the four power stations is shown in Table I.:—

TABLE I.—Turbine and Compressor Houses.

| | Kw. installed. | Length of turbine house. | Kw. per ft. run. | Kw. per sq. ft. | Plant installed. |
|---|---|---|---|---|---|
| | | | | | Kw. |
| Rosherville .. | 87,000 | 404 | 216 | 2·86 | 5 9,600 Turbine genrs.<br>6 × 3,000 Compressors.<br>3 × 7,000 ,, |
| Vereeniging .. | 43,200 | 153 | 273 | 3·78 | 2 × 9,600 Turbine genrs.<br>2 × 12,000 Generators. |
| Simmerpan ... | 40,000 | 327 | 122 | 2·10 | 2 × 12,000 Turbine genrs.<br>6 × 3,000 ,, ,, |
| Brakpan ..... | 31,000 | 325 | 95 | 2·64 | 2 × 12,500 ,, ,,<br>2 × 3,000 ,, ,, |
| Total installed.. | 201,200 | | | | |

TABLE II.—Boiler Houses.

| | No. of boilers installed. | *Nominal capacity of boilers at 15 lbs. per kw. | Area of boiler houses. sq. ft. | Kw. per sq. ft. |
|---|---|---|---|---|
| | | Kw. | | |
| Rosherville ........ | 40 | 89,600 | 46,482 | 1·93 |
| Vereeniging ........ | 20 | 18,000 | 24,168 | 1·98 |
| Simmerpan ....... | 24 | 12,600 | 28,980 | 1·47 |
| Brakpan ........... | 18 | 37,000 | 21,840 | 1·68 |
| Total ....... | 102 | | | |

* The nominal capacity is considerably less than the actual evaporation obtained in practice when burning reasonably good coal at normal draught. For instance, it is possible to obtain evaporation of 50,000 lbs. per hour from boilers rated at only 36,000 lbs.

At Simmerpan 16 small boilers are installed in two boiler-houses, and eight large boilers in a third boiler-house. The kw. installed per square foot in the small boiler-house is 1·22, and in the large boiler-house 1·78.

At Brakpan the eight small boilers occupy an area which gives kw. per square foot = 1·39, and the 10 large boilers kw. per square foot = 2·00.

## COAL BUNKERING AND HANDLING ARRANGEMENTS.

### Brakpan.

The Brakpan Station is so situated that the railway trucks can be shunted up an embankment direct into the overhead coal bunkers, the coal being dumped from hopper trucks of 40 and 50-ton capacity directly into the bunkers below. When the station was extended the same system was adopted. The bunkers are divided by bulkheads into nine divisions, four being over the small boilers, and five over the new and larger boilers. The capacity of each of the four small bunkers is 120 tons, and of each of the five large bunkers 375 tons. This arrangement, which appears to be so simple on paper, is most inconvenient in practice. No very serious difficulties were met with before the station was extended, and when the coal consumption was

* Abstract of paper read before the South African Institution of Engineers, and reproduced from the Journal of the Institution.

only about 1,300 tons per week, but now that the consumption has risen to 6,000 tons and over, the drawbacks and difficulties are considerable, due principally to the fact that it is impossible to mix the coals to obtain the most efficient results.

It must be admitted that as far as the coal handling costs are concerned the arrangement is a good one, but the approach to the coal bunkers is up a very steep embankment, which causes the shunting charges to be exceedingly heavy. An outside coal storage with elevators and conveyors would have reduced the shunting, but somewhat increased the handling charges. The principal gain, however, would have been in efficiency due to the possibility of mixing the coal, and the money value of this gain in efficiency would have paid a very handsome return on the additional capital cost involved by the outside coal storage and conveyors.

## Simmerpan.

An outside coal storage arrangement is provided at this station, consisting of a concrete and steel bunker having a capacity of 3,240 tons. This bunker is at right angles to the centre line of the boiler-houses. Gravity bucket conveyors run the full length underneath and deposit the coal to any one of the three gravity bucket elevators and conveyors taking coal to the overhead bunkers of the three boiler-houses; several fillers are provided, so that alternate buckets can be filled with different coals, enabling the coals to be mixed to give maximum efficiencies. The arrangement has worked perfectly and without trouble. All coals burnt at Simmerpan are either duff or a mixture of duff and peas. Our experience is that such coals can be burnt more efficiently when moistened, and this can be done very effectually either as the buckets empty themselves in the overhead bunkers or as they are being filled from the outside bunker.

## Rosherville.

At Rosherville the bunkering arrangements are generally similar to those at Simmerpan, except that the five staithes are in line with the centre lines of the five boiler-houses, and that the outside storage is not in the form of a bunker. Gravity bucket conveyors run the full length underneath the coal staithes, and the elevators convey the coal into the overhead bunkers above each boiler-house. The gravity bucket type of elevator and conveyor in practice has been found so reliable that the consulting engineer for the Rosherville Station deemed it unnecessary to have any considerable inside storage over the boilers.

There is considerable differences of opinion among power station engineers as to the advantage or otherwise of large overhead bunkers. In our opinion the local conditions are the deciding factor. Where ground is dear and space consequently limited it may be impracticable to have considerable outside storage, and in that case there is no option but to build bunkers over the boiler-house of the necessary capacity, bearing in mind the possibilities of irregular supplies. On the other hand, where land is relatively cheap, there is no doubt that an outside bunker is much the better arrangement, as not only can larger tonnages be more easily stocked, but the cost of the building steelwork is largely reduced, and a lighter and cleaner boiler-house results. The tendency in modern practice is, where possible, to store coal outside and have only the minimum inside storage. In this case the conveyors and supporting structure, and the small coal bunkers and chutes connecting them to the stoker hoppers, can be suspended from the roof principals. A further advantage of outside storage with minimum inside bunker is that one can draw upon any particular coal at any time with the certainty that it will reach the boiler to meet sudden changes of load, whereas with large overhead bunkers the choice of coals is somewhat restricted. The first four boiler-houses at Rosherville have only very limited inside storage; the fifth boiler-house is provided with an overhead bunker capable of holding 800 tons. As the boilers in this house are steamed steadily and continuously there is no very great disadvantage in the overhead bunker, although it is not necessary, and certainly added considerably to the capital cost of the buildings and interferes with the natural lighting.

## Vereeniging.

At Vereeniging the outside coal staithes are very similar to those at Rosherville, being arranged in line with the centres of the two boiler-houses. Bunkers are also arranged over the boiler-houses, each of a capacity of 1,000 tons. In this case also we should have done quite well without them; they interfere somewhat with the light and add considerably to the capital costs of the buildings.

## Coal Conveyors and Elevators and Weighing Machines.

Our experience with the gravity bucket elevators and conveyors has been almost uniformly satisfactory. They have proved most reliable in service, and the maintenance costs are not excessive. The most important factor in keeping maintenance costs down is to keep the conveyor clean and well lubricated; the automatic oiling device, while quite pretty in theory, does not work well in practice, and it is much better to put the conveyors in charge of a capable man. Even when well lubricated the bushes and axles wear in the course of time. The life of the bushes appears to be about four years' almost continuous running. The material from which they are made is usually too soft. We have recently fitted several conveyors with case hardened bushes, which, after several months' continuous running, show no signs of wear. The total operating and maintenance cost of all the conveyors and elevators on the system is given below, and averages 0·780d. per ton delivered into overhead bunkers.

OPERATING AND MAINTENANCE COST OF GRAVITY BUCKET CONVEYORS, 1915.

| Number of conveyors. | Total length. | Tonnage handled per annum (1915). | Operating and maintenance cost per ton. |
|---|---|---|---|
| | Feet. | Tons. | d. |
| 12 | 7,210 | 828,733 | ·780 |

## Weighing of Coal.

To correctly weigh coal in such quantities as are used in large power stations is a much more difficult problem than one would imagine, and a very considerable error in stock can be made when tonnages in the region of 1,000 to 1,400 tons per day are handled. The importance of correctly weighing coal will be realised when it is understood that the knowledge of the boiler-house efficiency is wholly dependent upon correct returns.

At Brakpan and Simmerpan no weighing machines are used. The coal is measured by levelling the bunkers, which are calibrated to definite volumes per foot depth. If the bunker capacity is relatively small this method of measurement is capable of giving accurate results, and it is impossible for an accumulative error to be made. At Simmerpan the maximum stock carried is about 3,500 tons and at Brakpan about 2,500 tons. At Rosherville the

stock frequently reaches 12,000 tons, and has on occasion reached between 15,000 and 16,000 tons. When this occurs considerable expenses are incurred in trimming and handling, and it is very difficult to estimate whether the stocks are in accordance with the book figures. At Vereeniging the maximum stock carried is about 7,000 tons.

Blake-Denison continuous weighing machines are provided at Rosherville and Vereeniging, and with great care and frequent calibration, and a knowledge of the bias of the machines, a fairly reliable return can be obtained. It may be said that the methods adopted for weighing coal in power-station work leave room for considerable improvement. The weighing of coal is a fundamental measurement, and the more accurately it is effected the more confidence one has in the station returns.

The stocks at Rosherville and Vereeniging are checked at the end of each quarter by a careful survey. It is not unusual to find an error of between 1,000 and 2,000 tons either plus or minus. This would represent a continuous error of between 1 and 2 per cent.

The coal is delivered from the overhead bunkers, whether large or small, by chutes, valves, or measuring "drums" being fixed between the bunker and the top of the chute. At the earlier stations (Brakpan and Simmerpan) measuring drums of a known capacity were fitted; a counter was attached so that the measured quantity of coal passed per shift or per day was known. These proved unsatisfactory, as the duff coals do not run freely, especially when wet, so that the drums did not fill properly. As a consequence no reliance whatever could be placed upon them, and all subsequent bunkers were provided with the well-known Babcock and Wilcox coal valve. The chutes are usually about 10 in. diameter, and have splayed bottoms where they discharge the coal into the stoker hoppers. We have found that the makers usually provide these of too thin a plate—$\frac{1}{8}$ in. or $\frac{3}{16}$ in.—and as a result they are rapidly corroded away on the bottom side, especially when dealing with wet coal. At Vereeniging the coal chutes are rectangular in section, which renders them much easier to repair. The bottom plate can easily be renewed, this being impossible when the chutes are of round section. In the earlier installations the discharge end was splayed to about half the width of the stoker hopper. This was found to give an unequal distribution of coal, the peas or larger pieces of coal falling to the sides, and the duff and powder falling in the centre, resulting in uneven fires. An improvement has been effected by making the width of the splayed bottom equal to the full width of the stoker hopper, and as the chutes are replaced this design is being adopted, but even with these there is a tendency for the larger particles of coal to fall to the side and make a somewhat uneven fire.

*(To be continued.)*

## THE INSTITUTION OF AUTOMOBILE ENGINEERS.

The seventh meeting of the session of the Institution of Automobile Engineers will be held on Wednesday, 11th April, 1917, at the Royal Society of Arts, John Street, Adelphi, W.C., at 8 p.m., when Lieut.-Col. R. K. Bagnall Wild will read a paper entitled "The Use and Abuse of Steel in Aircraft Construction."

An invitation is extended to all those interested in the subject to be present at the meeting, and a card of invitation may be obtained by forwarding a stamped, addressed envelope to The Secretary, Institution of Automobile Engineers, 28, Victoria Street, London, S.W.1.

# New Companies Registered.

APPLIANCES LTD. (146,341). Private company. Registered March 7th. Capital, £1,000, £1 shares. Engineers, brass and ironfounders, wire drawers, tube makers, etc. Table "A" mainly applies. Solicitor: J. H. Glover, 60, Castle Street, Liverpool.

CLYDACH ENGINEERING CO. LTD. (146,403).—Private company. Registered March 10th. Capital, £1,000, £1 shares. Colliery, marine, mining, motor, aerial, electrical and general engineers, etc. Directors: H. R. Jones, J. Arnold, D. O. Williams. Registered office: Clydach, Swansea Valley, Glam.

JOHN DAWSON AND CO. (NEWCASTLE-ON-TYNE) LTD. (146,365).—Private company. Registered March 8th. Capital, £5,000, £1 shares. Aircraft manufacturers, engineers, founders, smiths, etc. The subscribers are to appoint the first directors. Registered office: 2, Collingwood Street, Newcastle-on-Tyne.

MINCHIN ENGINEERING CO. LTD. (146,388).—Private company. Registered March 9th. Capital, £1,000, £1 shares. Motor engineers, etc. Agreement with A. Minchin. A. Minchin is the first director. Registered office: 39, Penrhyn Road, Kingston-on-Thames.

T. AND R. LEES LTD. (146,377).—Private company. Registered March 8th. Capital, £50,000, £1 shares. To take over the business of mechanical engineers and ironfounders carried on by R. Lees, senior, Wm. Lees, Walter Lees, and R. Lees, junior, at Hollinwood, Oldham as "T. and R. Lees." Directors: R. Lees (permanent chairman), Wm. Lees, Walter Lees, and R. Lees, junior. Registered office: Park Ironworks, Hollinwood, Oldham.

CENTRAL ENGINEERING CO. LTD. (146,584). Registered March 17th. Capital, £1,200, £1 shares. Motor, cycle, and aircraft manufacturers, electrical and general engineers, etc. Directors: A. Wax and H. Halfin. Registered office: 7-9, Farm Lane, Walham Green.

F. READER AND SONS (146,472).—Private company. Registered March 14th. Capital, £20,000, £1 shares. To take over the leasehold "Phœnix Works," Nottingham. Engineers, founders, smiths, boiler makers, etc. The subscribers are to appoint the first directors. Solicitors: Mills and Morley, 38, Lincoln's Inn Fields, W.C.

JOSEPH BRIGGS LTD. (146,555). Private company. Registered March 16th, by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C. Capital, £12,000, £1 shares. To take over the business of ironfounders and engineers carried on at Barrow-in-Furness, as "Joseph Briggs." Agreement with R. F. Matthews. Solicitor: R. B. D. Bradshaw, 7, Lawson Street, Barrow-in-Furness.

RENSHAW ENGINEERING CO. LTD. (146,484). Private company. Registered March 14th. Capital, £5,000, £1 shares. Mechanical, electrical, and general engineers, etc. Directors: T. P. Hartley and C. E. Holder. Registered office: 27, Chatham Road, Battersea, S.W.

AMERICAN SHIPBUILDING.—Contingent upon the fact that satisfactory contracts as to prices and delivery cannot be made with private yards, the Naval Appropriation Bill for 1918 (says *The Iron Trade Review*, Cleveland, Ohio) carries a provision appropriating 12,000,000 dollars for the use of the Secretary of the Navy in enlarging navy yards for the construction of all classes of ships. It also raises the limit of cost of battle-cruisers from 16,500,000 dollars to 19,000,000 dollars, and of scout-cruisers from 5,000,000 dollars to 6,000,000 dollars each. At the recent hearing before the House Committee it was plainly pointed out that this action would have to be taken regardless of whether the said cruisers were built in Government or private yards. The action of the Committee, adds our contemporary, will greatly simplify the situation as to the construction of the four battle-cruisers and three scout-cruisers of the 1917 programme which remain to be awarded, provided the Secretary of the Navy abandons his hostility towards private builders. If he does not, the situation will continue to be a deplorable one, as it would mean the enlargement of navy yards before beginning construction of these seven vessels, to say nothing of at least some of the vessels of the 1918 programme. But despite his bitter attacks on private shipbuilders as to their so-called unreasonable terms in connection with the building of the cruisers, it is believed that the Secretary will lose no time in making use of the increased limit of cost to award all seven of them to private yards.

# Trade Items, Notes, &c.

New Munition Plant.—A new plant for the Imperial Munitions Board is to be installed in Ashbridge's Bay, Toronto. It is stated that the plant will finally occupy 60 acres of reclaimed land, and cost £600,000. It will have an initial capacity of 300 tons a day. In a statement issued by the Harbour Commission, it was mentioned that there will be ten 6-ton 3-phase 25-cycle Heroult-type electric furnaces of about 2,000 H.P. each.

Coal-cutting Machines.—In 1915 there were 638 collieries in the United Kingdom where coal-cutting machines were at work as against 652 in the preceding year. The total number of machines employed was 3,089 (as against 3,093 in 1914), of which 1,449 were worked by electricity and 1,640 by compressed air; the total quantity of mineral obtained in 1915 by the aid of these machines was 24,510,124 tons; this is an increase of 235,607 tons compared with 1914.

Oil-burning Locomotives in the States.—Figures submitted by the U.S. geological survey show that the railroads of that country consumed in 1915 36,648,466 barrels of oil fuel, or 18 per cent over 1914. The total distance covered by oil-burning locomotives in 1915 was 124,255,525 miles and the average distance covered per barrel of oil fuel consumed was 3·39 miles. Oil fuel at the beginning of 1916 was used to some extent on 40 railroads in the United States.

Shipbuilding Activity in Sweden.—The Götawerk shipyard, in Gothenburg, is doubling its capital, from 2,200,000 to 4,400,000 kronor. The recently-formed Oresund yard, in Landskrona, on the Sound, is increasing its capital from 600,000 to 4,200,000 kronor. Old-established yards will find that the war and the exceptional conditions it has created have vastly increased the shipbuilding capacity in almost every country. (1 krona = 1s. 1½d.)

Stimulated by the war, the zinc-smelting capacity of the Empire has been considerably increased, and it may be of interest to note that the Ridge Roasting Furnace and Engineering Company have supplied plant for this purpose to four different smelters, and have just received a repeat order from Messrs. Vivian and Sons Limited, of Swansea, for further roasting plant. The fumes are to be used for making sulphuric acid.

The French Government has issued a decree declaring the widening and deepening of the Caen sea canal a work of public utility. The British Vice-Consul is informed by the chief engineer of the Department of Calvados that foreign firms will be allowed to tender for work in this connection. The conditions of tender have not yet been drawn up—the preliminary acquisition of land having not yet been effected—nevertheless British contractors who, in due course, may wish to tender are invited now by the engineer-in-chief to get into touch with him, informing him on what terms they would be able to undertake the construction of the whole or part of these works.

Trade Losses of Germany.—It is estimated that since she declared war Germany has lost five billions of trade (says *The Marine Journal*, New York). The loss to the British Empire has been nearly one billion dollars, to France as much, and to Russia half a billion. She has lost in imports from the British Empire, raw materials, produce and manufactures, nearly 600,000,000 dollars; over 700,000,000 dollars from Russia, and from France about 350,000,000 dollars. The figures are not exact, adds the American journal, for war trade statistics cannot be wholly accurate. Trade takes underground routes during hostilities, or Germany would have now been prostrate. The leakage into Germany through neutral neighbours may perhaps have been all that has kept her army going.

Wooden Shipbuilding in U.S.A.—For the first time detailed returns are given by the Bureau of Navigation, Washington, of the extent of the present remarkable revival in wooden shipbuilding in the United States. These returns show that on January 1st wooden vessels of 500 tons gross or more which were being built or were under contract to be built in private yards in the United States numbered 161, and were of 207,623 tons gross, thus averaging about 1,290 tons each. Of these vessels, 83 of 136,718 tons were to be driven by engines, and the remainder were either sailing vessels or were unrigged. Fifty-two of the total number were being built on Puget Sound and Columbia River, 36 on the Middle Atlantic Coast, 35 on the South Atlantic and Gulf Coasts, 26 in New England, and 12 on the coast of California.

Broken Pulleys.—A broken cast-iron pulley was recently repaired by pouring it full of concrete. The pulley, which is one of a pair carrying the main elevator in a large stone-crushing plant, is 54 in. in diameter, with a 20 in. face. In the failure nearly the entire rim was broken, but an extra pulley was not available, and it took some time to secure a new one. To avoid shutting down the plant in the meantime, a form was built in place around the remains of the old pulley, using perforated metal, faced with building paper for the rim and wood for the sides. The belt was left in place, and the whole interior of the form poured full of 1 : 2 : 3 concrete. Pouring was finished at 6 p.m. on Saturday, and the concrete pulley was put in service at 11 a.m. the following Monday. The job is said to have been a complete success. The belt runs directly on the concrete.

Technical Training.—In an address to the educational authorities of the County of Durham, Lord Haldane pointed out that we must pay more and more attention to education and technical training. Three-quarters of a century ago, he went on to say, the captain of industry was the energetic capitalist, but the old-fashioned man of business had now gone, and the joint stock company had taken his place. The organiser had become the supreme force in industry, but that organiser only succeeded in so far as he called to his aid science. It was not only the manager who needed science, but the workman who was employed upon complicated and intricate machinery; he needed knowledge, too. This was the state of things in the struggle which was to follow the war. If he had his way he would give the son, and the daughter, too, of every working man the chance of such an education as would enable that young person to rise to the position of a great discoverer or inventor.

The Nitrogen Industry in Sweden.—The fact that the import of artificial manures has been greatly jeopardised by the war has increased the interest taken in the new Swedish nitrogen industry, which has started on the West Coast. The original company has now increased its capital to 8,000,000 kronor, with an option of a further increase to 24,000,000 kronor and manufacture on a large scale is understood to be impending. The method of production is stated to be entirely different from the Norwegian method, as practised by the Norsk Hydro Company. The furnaces of the Swedish company gave a good deal of trouble at the start, and comprehensive experiments were necessary to arrive at satisfactory results, which, however, are now said to have been obtained; there have also been difficulties with regard to raw materials. The furnaces are planned in sets of four, and efforts are now being centred upon getting one set finished, and four such sets are contemplated. It has, however, been stated that three furnaces would suffice for Sweden's requirements. Sulphate of ammonium will be the primary product, but the working programme also comprises the manufacture of nitrates on a large scale.

Blast-furnace Gas Cleaning.—The electric treatment of waste gases and fumes is decidedly gaining adherents in the United States. Discussing the question, "Dry-hot *versus* Cold-wet Blast-furnace Gas Cleaning," in the February Bulletin of the American Institute of Mining Engineers, Messrs. L. Bradley, H. D. Egbert, and W. W. Strong sum up in favour of the former treatment with respect to the economy of using the gas in hot-blast stoves and under boilers. They rely largely on the data on specific heats of Kuzell and Wigton and on a communication by W. Mathesius, "High-blast Heats in Mesaba Practice"; these communications were published in the Transactions of the same institute, 1914 and 1915. The cold-wet scrubbing of the top gas from blast furnaces, it is pointed out, removes part of the moisture from that gas; at the same time the temperature of the gas is very much lowered, the flame temperature is likewise lowered, therefore, and heat is lost. The electric treatment of the hot gases cleans the blast-furnace gas almost completely, leaves a high temperature, admits of easy recovery of valuable products (metals, potash, etc.), keeps boilers and stoves cleaner, and prevents trouble from slow ignition and imperfect combustion. It is also said that cold washing of the gas requires large and expensive installations and gives troublesome amounts of muddy water. Nothing is said about the expense of the electric precipitation.

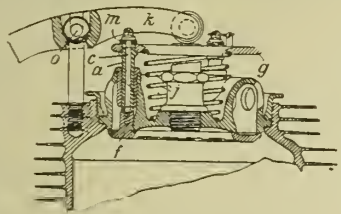
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### FLUID-PRESSURE ENGINES.

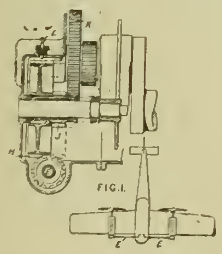
103,150.—J. ZEITLIN, 115, Bishop's Mansions, Bishop's Park Road, Fulham, London. Jan. 12th, 1916, No. 542. Addition to 15734/13.—The valve mechanism described in the parent Specification is modified by mounting the rods *c* by means of which the valve *f*




is held to its seat, inside the tubular rods *a*. The upper ends of the tubular rods engage a ring *g*, which is depressed to open the valve by a bifurcated rocking-lever *k* mounted on a spherical-ended rod *o*. The underside of the ring is engaged by a spring *j*. Spring washers *m* are inserted between the ring and the retaining-nuts on the rods *c*.

### ENGINE-TURNING GEAR.

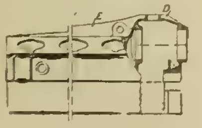
103,158. SUNBEAM MOTOR CAR CO. and L. COATALEN, Moorfield Works, Wolverhampton. Jan. 18th, 1916, No. 779.—Motion is transmitted from the starting-shaft E to the engine shaft through a sliding wheel H and pinion J. The wheel H has helical teeth, and



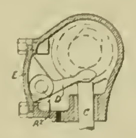

owing to its inertia or to its engaging a pin L, it is prevented from rotating when the shaft E begins to turn; it is therefore slid along the shaft, and the pinion J is brought into gear with the wheel K on the engine shaft. The gear may be used, as shown in Fig. 1, to start two motors on opposite sides of the fuselage of an aeroplane.

### INTERNAL-COMBUSTION ENGINES.

103,159. SUNBEAM MOTOR CAR CO. and L. COATALEN, Moorfield Works, Wolverhampton. Jan. 18th, 1916, No. 780.—In an aviation engine of the V or other type having two or more rows of cylinders, the speed-reduction gearing between the engine and propeller shafts is located in an extension D of the crank casing, the combined casing and extension being stiffened both by a longitudinal web E, which extends throughout the length of the crank casing, and by smaller transverse and longitudinal webs (not shown). The extension D may be integral with, or separate from, the crank casing.




Patent 103,159.



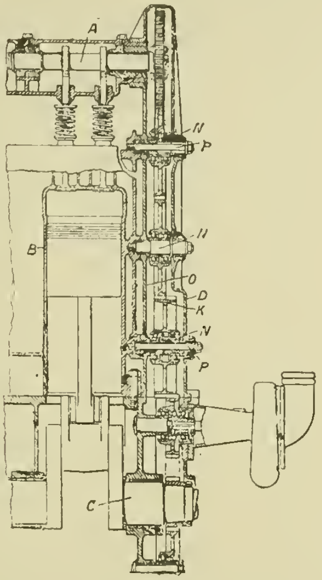
Patent 103,160.

### INTERNAL-COMBUSTION ENGINES.

103,160. SUNBEAM MOTOR CAR CO. and L. COATALEN, Moorfield Works, Wolverhampton. Jan. 18th, 1916, No. 781. A detachable overhead casing for a camshaft has a sump A2 which collects and thus prevents escape of lubricating oil past the valve tappets C. The casing has a removable cover E which carries rockers D engaged by the valve cams. A removable cover may be provided on the opposite side of the casing.

### INTERNAL-COMBUSTION ENGINES.

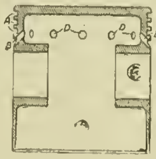
103,163. SUNBEAM MOTOR CAR CO. and L. COATALEN, Moorfield Works, Wolverhampton. Jan. 18th, 1916, No. 784. In engines in which the camshaft A is arranged above the cylinders B and is driven from the crankshaft C through spur gearing, one or more of the wheels, for example one wheel K, is made of greater width than the adjacent wheels, in order that the top wheel may be nearer the cylinder than the lower ones, so permitting the use of




a short camshaft. Each wheel is mounted on a tubular distance-piece N carried partly by the casing O and partly by the cover-plate D, and is held in place by a stud P.

### PISTONS.

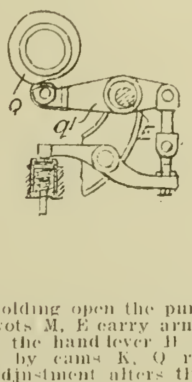
103,164.—SUNBEAM MOTOR CAR CO. and L. COATALEN, Moorfield Works, Wolverhampton. Jan. 18th, 1916, No. 785. One or more grooves B are arranged beneath the packing grooves A to collect

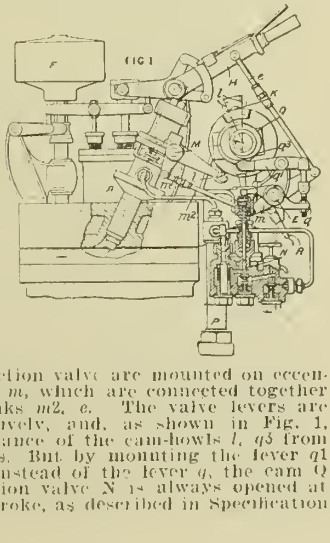



oil and pass it to the interior of the piston. The section of the groove is roughly triangular with the apex downward, and upwardly-extending passages D lead therefrom to the interior of the piston.

### INTERNAL-COMBUSTION ENGINES.

103,177. VICKERS LTD., Vickers House, Broadway, Westminster, and J. MCKECHNIE, Naval Construction Works, Barrow-in-Furness, Lancashire. Jan. 20th, 1916, No. 964.—Both the liquid-fuel injection valve A and the suction valve N of the fuel pump are controlled by mechanism which is adjusted simultaneously by the governor F, and which can be disconnected from the governor and adjusted by a hand-lever H. The fuel-valve lever and the lever



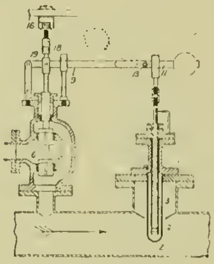



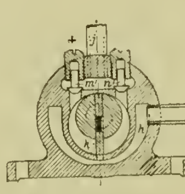

*q* for holding open the pump suction valve are mounted on eccentric pivots M, E carry arms *m*1, *m*, which are connected together and to the hand lever H by links *m*2, *e*. The valve levers are worked by cams K, Q respectively, and, as shown in Fig. 1, their adjustment alters the distance of the cam-bowls *l*, *q*5 from the axis of rotation of the cams. But by mounting the lever *q*1 adjustably, as shown in Fig 2, instead of the lever *q*, the cam Q can be shaped so that the suction valve N is always opened at the same point in the suction stroke, as described in Specification

18,095/15. The fuel is delivered through a resilient accumulator P as described in Specification 26,227/11. The sucton valves may be held open permanently by a hand-lever R.

### STEAM SUPERHEATERS, ETC.

103,196. P. A. W. PARKYN, Queen Anne's Chambers, Westminster. Feb. 16th, 1916, No. 2,316. Relates to apparatus for regulating the temperature of superheated steam or vapour of the kind in which a thermostat in the steam or vapour pipe 1 operates a valve 6 controlling the admission of saturated steam or vapour to the pipe. The thermostat consists of an outer tube 2 containing mercury or other expanding substance, an inner tube 3 open at its lower end, and a piston or float 4 within the inner tube. The valve may be held in its closed or open positions by lowering or raising, by a hand-wheel 16, a stirrup-piece 18 engaging with a head 19 on the valve stem. The lever 9 connecting the thermostat to the valve stem has a pivoted and weighted end 11, which is normally locked by a bolt 13. The thermostat may be connected to the valve stem through toggle-levers.


Patent 103,196.

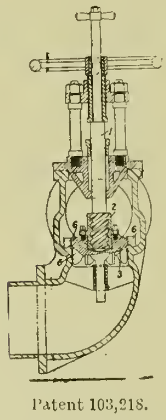

Patent 103,199.

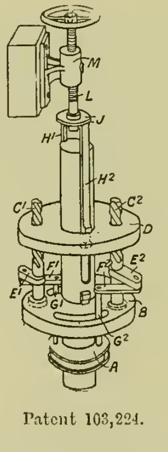
### ROTARY PUMPS.

103,199. T. SIMPSON and W. SIMPSON, 26, Collingwood Street, Newcastle-on-Tyne. Feb. 21st, 1916, No. 2,586. A rotary reversible pump for liquids has an inlet port $k$ in communication with a priming-chamber $h$, and delivery valves $m1$, $n1$, one or other of which is automatically opened according to the direction of rotation. The supply to the delivery pipe $j$ is thus independent of the direction of rotation. The two valves $m1$, $n1$ may be replaced by a single ball valve, which moves automatically to close one or other delivery port.

### VALVES.

103,218. COCKBURNS LTD., D. COCKBURN, and D. MACNICOLL, Cardonald, near Glasgow.—March 24th, 1916, No. 4,253.—A self-closing emergency stop valve of the type described in Specification 26,421/12, in which a lift valve 3 is rotated to its closed position by the fluid flow acting on the vanes 5 secured to the valve member, has guide-vanes 6 formed on the casing, and has the valve member formed or fitted with an internally screw-threaded part 2 adapted to engage a correspondingly threaded part on the spindle 1 used for manual actuation.


Patent 103,218.



Patent 103,224.

### RECIPROCATING PUMPS.

103,224. E. W. PETTER, Nautilus Works, Yeovil, Somerset. April 6th, 1916, No. 5,078. In the fuel pump of an internal-combustion engine, the time of injection of the fuel is varied by angularly adjusting on the crankshaft the eccentric A which actuates the pump. The apparatus comprises a fixed flange B on the engine shaft, in which are revolubly mounted two screwed rods C1, C2 passing through threaded holes in a disc D. The disc D is mounted on two feathers H1, H2, which slide in keyways in the shaft and are attached to a disc J. When the disc J is moved by turning the screwed rod L in the fixed nut M, the disc D moves along the shaft and rotates the rods C1, C2, thereby adjusting the eccentric A through the links E1, E2, F1, F2, G1, G2.



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# Industrial Engineer.

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# EDITORIAL.

## PATENTEES AND THE PROLONGATION OF PATENTS.

### A Preliminary Statement.

Amongst the many problems which beset the body politic in these strenuous warlike days there is one which has a particular bearing upon the interests of patentees and those owning British patents. Before, however, dealing with the principal points to which we desire to draw attention, it may be as well, to save misconception, to re-state what almost every owner of a patent should know, but, curiously enough, some do not, that the issue of Letters Patent at all confers a sole monopoly to the inventor, or right to make, vend, and generally exploit his invention for 14 years. In short, it is a definite legal contract between the inventor and the Crown, the latter through the machinery provided to that end, asking for the fulfilment of certain conditions by the inventor in order that he may retain his monopoly. We need not here enter into a statement of the whole of the considerations upon which a patent is granted, as in what we are about to say they are not germane. The main points that concern us are that a patent is granted for 14 years conditionally upon the payment of yearly renewal fees, and that so long as this is done the patentee's rights, be they otherwise good, bad, or indifferent, either industrially or legally, are presumed to exist and are good against infringers until proved otherwise.

### Patentees and the War.

This aspect of the question being thoroughly understood, let us see how the patentee stands under war conditions. If his invention is a serviceable one for warlike purposes, he may be one of those few lucky individuals said to be "in clover." We need not, therefore, be unduly anxious on his account. We congratulate him: he deserves his fate. But there are others, and a great many, too, who, as a result of the war, have been quite unable to exploit their inventions at all. Some of such inventions may not even have been exploited in any case in peace time. That also is beside the point. Even meritorious inventions, it is generally admitted amongst engineers, take at least four years' persistent push to become even partially recognised by that part of the public they concern, and if that first four years in the life of the patent was just previous to the war, then there has to be added to the period during which the war has run, in which it is assumed nothing has been done. Here, then, we have an unremunerative seven years, or half the full life of the patent monopoly, and with the possibility of a long period to add to it yet. Even if we take only the period of the war as far as it has run and a reasonable assumption that it will run to next August, we have a solid three years' cut out of the useful life of the patent. Then again, we have the case of those inventions which were already bringing in reward to their inventors when the war broke out, and which, as a result of the war, are now sterile. There are thousands of such. We might put forth many other cases. What we are concerned about is the question of the aforesaid contract between the Crown and the patentees. Clearly in these cases the contract has been broken, not deliberately we, of course, admit, by the Crown itself. It would, therefore, seem to be up to the Crown to put the patentees on an equitable footing again by extending their monopoly for a period at least equivalent to the war's duration. We would here say that even supposing an invention had been monetarily very successful in pre-war times that should be no bar to extension beyond the period for which the patent was originally granted so long as an

ineffective period had been cut out of its legal life by the war. It should generally be remembered when considering the question that patentees suffer the other disabilities of war along with other subjects.

### Inventors on National Service.

In the foregoing remarks we have only dealt cursorily with the general aspect of the case out of consideration for the space we have at disposal, but it must be remembered there are many other aspects of equal importance. There is, for instance, the question of the sailor and soldier patentee and many others who are engaged on national service of some kind which precludes them exploiting their inventions. To refuse to grant them an extension in their monopolies would be a grevious scandal and a poor recompense for the services they had rendered. In addition to these, there is the question of the treatment of British patents owned by Allied inventors and the patents owned by enemies. With regard to the latter, their owners deserve whatever bad fortune the wickedness of their own Governments bring upon them, but, of course, as to the former, nothing save the most liberal consideration should be extended to them. This would and certainly should be as magnanimous as the treatment meted out to our own inventors and patentees.

### Patentees must be Alert.

We understand on reliable authority that a Bill is being prepared to be presented to Parliament with a view of doing something on the lines indicated. This Bill is said to be the result of conferences between some London patent agents, solicitors, and barristers interested in patents, and the Comptroller of Patents and the Board of Trade. So far as the last two are concerned, the interests of patentees may be fairly safe in their keeping, but we are somewhat doubtful of the others. At any rate, we are not aware that patentees themselves, who are the parties most concerned in the subject, have been consulted at all. There are some firms who must have at least 500 patents in force, and it behoves these and others not so largely interested to act at once and make their voices heard on the subject, otherwise they may find the clauses of the proposed Bill anything but to their liking. There is some suggestion that a somewhat high fee should be paid to the Patent Office to have each case of a patent separately investigated either by the Patent Office or by a body specially created for that purpose. Such a suggested proceeding is ridiculous in the extreme, and whilst being capable of being easily met by wealthy patentees and owners would be disastrous to the less wealthy patentees. It behoves every patentee to take a personal interest in this matter without delay.

## VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES.

*(Concluded from page 245.)*

Petrol-electric systems are, without doubt, handicapped as compared with the sliding type of change-speed gears —at all events for use in pleasure and light commercial vehicles—first on account of excessive weight, and, secondly, on account of lack of power of rapid acceleration. As regards weight, it does not appear possible to make this compare favourably with the mechanical types of variable gearing without seriously risking its efficiency and even breakdown under severe duty. With respect to accelerations, it must be borne in mind that sudden acceleration of the engine—which in a purely mechanical transmission is at once transmitted to the road wheels—only results, in a petrol-electric system, in an increased generation of electricity in the dynamo, which is followed later by increased speed of the electric motor as the magnetic flux is built up in the generator, and therefore an appreciable time elapses before the current has had time to make its influence felt at the road wheels. For heavy commercial work neither the increased weight nor the sluggishness in acceleration is a matter of much serious moment, and the latter defect may even be a blessing in disguise, as it affords a means of cushioning any shocks that may be set up in the transmission system by unskilful or careless driving. As petrol-electric systems allow of maximum acceleration without subjecting any part of the vehicle to undue strain, they have, as compared with mechanical gears, the great advantage that it places the most incompetent driver on a par with the most experienced and careful driver using a mechanical gear, and it is questionable whether—at all events for commercial work—the inability to rapidly accelerate is not more than compensated for by the saving in wear and tear arising from absence of shocks and undue strain.

Comparing petrol-electric transmission with hydraulic transmission, there does not seem to be much between them on the score of being noiseless, of not being affected by the distortion of the frame of the vehicle, and of giving a smooth acceleration and retardation. Theoretically, each seems to be an ideal transmission for motor road-vehicles, and if this paper serves no other purpose it should at all events produce a discussion amongst the upholders of these two systems as to their relative merits, and it is not difficult to forecast that the upholders of these two systems will not be allowed to have it all their own way by the upholders of the sliding and epicyclic types of wheel gearing.

Neither the total losses on transmission nor the losses through the variable-speed gear alone under road conditions are accurately known, and will not be until some means is devised by which the actual power given out by the engine at any moment under and during running conditions can be accurately ascertained. From hill-climbing trials of cars whose maximum engine-power is known, the total losses in transmission have been estimated to vary from 20 to 50 per cent.

The Author desires to express his thanks to Mr. A. J. Boult; Mr. Granville E. Bradshaw, of the A.B.C. Motors Ltd.; Mr. F. Leigh Martineau, of Compayne Co. Ltd.; The Coventry Chain Co. Ltd.; The Cowey Engineering Co. Ltd.; Commercial Cars Ltd.; The Daimler Co. Ltd.; The Lanchester Motor Co. Ltd.; The Scottish Commercial Cars Co. Ltd.; Tilling-Stevens Ltd., and The Thomas Transmission Co. Ltd., for the information which they have so kindly given him.

### STEVENS ELECTRIC SYSTEM.

In the Stevens system a shunt-wound generator of the interpolar type producing a continuous current is driven directly by the engine, and a series-wound electric motor is coupled to the transmission shaft of the vehicle, a controller box, and a shunt resistance for the generator fields being provided. The generator, which is capable of an output of from 1 to 36 kilowatts at a speed varying from 350 to 1,400 revolutions per minute at a voltage varying from 0 to 300, is designed with a falling characteristic, so that any increase in the demand for current when the engine is fully loaded is accompanied by a corresponding reduction in voltage. The output in kilowatts at any speed is proportional to the power exerted by the engine,

but the volts and amperes vary over a large range, according to the gradiant of the road, the speed, or the degree of acceleration required. The amperes required by the series-wound motor are approximately proportional to the torque on the transmission shaft, and the speed of the motor is to a smaller degree proportional to the torque on the transmission shaft, and the speed of the motor is to a smaller degiec proportional to the voltage of the supply. Consequently, when the vehicle is running on a level road the demand for current is small, but on up-gradients it increases with a corresponding decrease in voltage, which results in a slower speed with increased torque. This change takes place automatically. The excitation of the generator ceases automatically when the engine speed falls below 250 revolutions per minute.

In ordinary running on the level, or on slight up-gradients, the speed of the vehicle is entirely regulated by controlling the speed of the engine by means of the usual gas throttle-valve; but on stiff up-gradients, heavy roads, under other conditions requiring greater power, the shunt resistance is employed to allow of increased engine speed. The controller has three positions—forward, neutral, and reverse. As the generator ceases to excite at 250 revolutions per minute of the engine no electrical circuits are required to be made or broken in driving, even when stopping in traffic, as by reducing the speed of the engine to 250 revolutions per minute, or less, by means of the throttle valve, the generation of current is stopped, and therefore no power is transmitted to the road wheels. Owing to the inter-polar construction of the generator sparkless commutation is ensured, and as the main circuit is never broken during driving, no sparking occurs at the contacts. At starting, the electric motor demands a large current to develop the necessary torque for starting, which the dynamo supplies at a low voltage, and as the motor speeds up, it automatically demands less current, which is supplied by the generator at an increased voltage. In other words, the voltage of the generator varies in inverse ratio with the amperes output, therefore the power required to drive the motor can never exceed a predetermined maximum, which is arranged to correspond to the maximum power of the engine.

## GERMAIN ELECTRIC SYSTEM.

In the Germain system, which of all the systems most nearly approaches the purely electrical change-speed gear, the electrical transmission is only employed while the vehicle is being accelerated to such a speed that the prime mover can deal with the load direct, at which time it is coupled directly to the transmission mechanism through a magnetic clutch. Two series-wound dynamos are employed. The field magnets of one dynamo are fixed on the crankshaft of the engine and rotate with it and incidentally take the place of the flywheel, and the field magnets of the other dynamos are permanently fixed. The armatures of the two dynamos—each of which has its own commutator—are mounted on a shaft which is arranged in axial alignment with the crankshaft of the engine and is connected to the road wheels by suitable transmission mechanism. The dynamo coupled to the engine acts either as a dynamo or as a magnetic clutch, and the other dynamo acts for the most part as a motor, but is also used as a dynamo for "braking" purposes.

Variations of speed of the car are effected entirely by a controller which makes the necessary electric connections between the dynamo, the motor, and a variable-resistance coil. Assuming that the engine has been started and that the car is at rest, the electric circuit is open throughout, so that no current is generated, and the armature of the dynamo remains stationary. To start the car the controller is operated to connect the dynamo in series direct to the motor, whereupon the car will travel at a speed dependent on the work it is called upon to do. The power imparted to the driving wheels of the vehicle is now partly derived from the magnetic pull of the field magnets of the dynamo on its armature and partly from the pull of the motor. The faster the vehicle runs the more nearly the speed of the armature of the dynamo corresponds with the speed of the field magnets, and consequently the amount of current supplied by the dynamo to the motor becomes less and thereby reduces its speed and the amount of work it will perform. The reduction of current, however, also affects the pull of the field magnets of the dynamo on its armature, on account of the magnetism of both being reduced. On the other hand, the slower the vehicle runs the greater is the relative speed of the armature and field magnets of the dynamo, with the result that the clutch effect between these two parts is increased and the power of the motor becomes greater. To increase the speed of the vehiclo, the controller is operated to introduce the resistance across the field magnets of the motor, which increases the speed of the motor and increases the current flowing through the main circuit, and therefore also the magnetic pull of the dynamo. By reducing the value of the resistance through the action of the controller the speed of the vehicle can be gradually increased until the field magnets of the motor are completely short-circuited. When this result is attained there is only sufficient relative movement between the armature and field magnets of the dynamo to generate the necessary current to magnetise these parts so that they operate as a clutch. To enable the mechanism to be used as a brake the controller causes the circuit to be so altered that the functions of the dynamo and the motor are reversed.

## THOMAS ELECTRIC SYSTEM.

In the Thomas system, which is diagrammatically shown in Fig. 28, the essential feature is the introduction of a planetary gearing, and it can best be described as an epicyclic gear in which the brake employed to retard or stop the rotation of one of the elements of the train takes the form of a resistance set up in an electrical machine, and in which the current generated in said electrical machine is employed to augment the power of the prime mover through a suitable motor. In this system three essential elements are employed, namely, a planetary gear and two series-wound electrical machines. The casing A of the planetary gear fixed on the crankshaft V takes the place of the flywheel of the engine. The planet pinions B and C, of which there are two or more groups, are of different sizes, each group being mounted on a shaft D carried by the casing A. These planet pinions gear with two sun-wheels E and F—also of different sizes—which are fixed respectively on an extension G of the crankshaft V and on the end of a hollow shaft H which fits over the extension G. On the shaft H is mounted the armature J of one

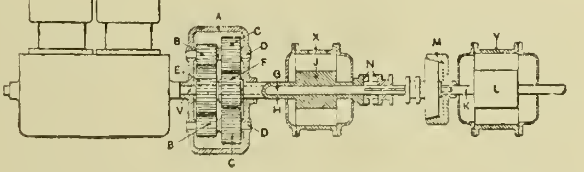



Fig. 28.—Diagram of Thomas Electric System.

of the electrical machines X, and on a shaft K, which is arranged in axial alignment with the shaft G, is mounted the armature L of the other electrical machine Y. The shaft K is coupled to the shaft G by means of a friction clutch M, and a couple in the form of a positive clutch N is provided between the shaft G and the shaft H. The two electrieal X and Y are connected in series. There are thus two paths through which the power from the engine can be transmitted to the road wheels, the one a mechanical one through the pinion E and the shafts G and K, and the other an electrical path through the pinion F and the two electrical machines X and Y. Assuming a given rotation of the casing A, as the pinion E is larger than the pinion F, the pinion F and with it the shaft H and the armature J will tend to rotate backwards, and the pinion E and with it the shaft G and the armature L will tend to rotate forwards at speeds depending on their relative resistance to motion, and thus if the speed of the engine is constant the speed of the shaft G will vary as the speed of the shaft H, and since the speed of H depends upon its resistance to motion, and therefore on the load of the electrical machine Y, the speed of G can be varied by varying the power transmitted electrically between the armatures L and J, which is obtained by varying the strength of the fields of the two electrical machines by means of a suitable controller.

The operation of this transmission is as follows: Before starting there is no electrical connection between the two electrical machines X and Y, so that the shaft H and the pinion F rotate backwards while the pinion E remains stationary. To start the vehicle, current is taken from the electrical machine X to the electrical machine Y. This has a double effect upon the shaft G. The current transmitted to the armature L exerts a torque on the shaft G, and the loading of the armature L with this current by decreasing the speed of the pinion F and the shaft H causes the pinion E and the shaft G to rotate.

A part of the torque is thus transmitted electrically and a part mechanically. As the armature J of the electric machine X is gradually decreased in speed the vehicle increases in speed until the shaft H, and with it the armature L of the electrical machine Y, practically comes to rest. Up to this point the electrical machine X has been acting as a dynamo and the electrical machine Y as a motor. Both machines now change their functions, power being transmitted from Y to X. Owing to the shaft H being forced to rotate against and in the same direction as the engine, the speed of the shaft G still further increases. The speed of the shaft H increases more rapidly than that of the shaft G, due to the gear ratio in the planetary gear, until finally they both travel at the same speed. The coupling N is now engaged so that the engine drives direct through to the transmission shaft. To obtain the reverse, the coupling N is engaged and the clutch M disengaged. The armature J of the electrical machine X is then rotated by the engine and the current generated by the machine is transmitted to the electrical machine Y, which is given a reversed field. The electrical machine X—connected up as a shunt machine—may, when the engine is driving direct on to the transmission shaft, be employed to charge a set of accumulators, which can be used through the medium of the same electrical machine to start the engine.

*(Concluded.)*

# COAL AND ITS CONSUMPTION.

By W. H. Casmey.

*(Concluded from page 250.)*

### Automatic Dampers.

Many boilers are now fitted with dampers which automatically close when the steam pressure reaches blowing-off point, and open again when the pressure falls. Taking this apparatus at the first glance, the suggestion looks good, but under examination a flaw quickly appears. If the steam is at blowing-off point it is to be expected the fires are in good condition. If then the dampers close we have furnaces at, say, 2,500 deg., and the boiler heating surface at 370 deg. The transference of heat from the higher to the lower temperature is very rapid, consequently when the dampers open the furnace temperature is so far reduced that combustion for about 10 to 12 minutes is poor, and, judged from the $CO_2$ standard, 4 per cent below the reading before the dampers were closed.

### Airtight Brickwork.

The surrounding brickwork of the boilers should be kept as airtight as possible, and the inside of all brickwork well brushed when the boilers are off for cleaning. This allows much of the convected heat being converted into radiant heat and returned to the boiler. The feed water, as a rule, is delivered into the boiler above the furnace flues, in the very section where ebullition takes place. This is wrong, as the feed should enter at the bottom of the boiler, thus promoting circulation and preventing the incoming water obstructing the rate of steam production, besides assisting in keeping the furnace flues free from scale. Another item in connection with the boiler is the height of the water. This should not be above the ordinary working level, as the higher the water the more fuel is required to keep it in active ebullition, and the smaller the steam space for the engine to draw from.

### Economisers.

The economiser is a useful part of a steam plant, if used with discretion, by which is meant, do not allow the water to reach an abnormal temperature, 200 deg. to 220 deg. being high enough. This statement may occasion surprise to some, but consider the water in the economiser is only a means of intercepting the waste heat from the boiler; therefore, if its temperature is high, it indicates a proportionately high temperature of the escaping gases from the boiler. To illustrate this point, our boiler is burning 1,000 lbs. of coal per hour, using the minimum quantity of air, 15 lbs. per pound of coal, the temperature of gases leaving the economiser 500 deg., and another test the temperature 400 deg. The higher temperature given takes away the heat value of 28 lbs. of coal every hour; this, in 56 hours, equals 14 cwts. If, however, we allow 25 lbs. of air per pound of coal, the wastage for the 100 deg. difference in temperature is 22 cwts. per week, and this figure is in many cases exceeded in present-day practice.

### Induced Draught.

Time does not permit us to discuss the subject of induced or fan draught in detail. We may, however, point out it is one of the ways by which wastage can be avoided. A chimney dealing with four boilers, each consuming 1,000 lbs. of coal per hour, and using 15 lbs. of air per pound of coal, the temperature of the gases leaving the economiser being 450 deg., the external temperature 50 deg., uses for producing its draught 4 cwts. of coal per hour, or about 10 per cent of the total fuel used by the boilers; or, if we calculate at the present-day supply of 25 lbs. of air per pound of coal, the chimney draught costs 7 cwts. per hour. An induced draught fan costs to drive about one-tenth the fuel required by the chimney. The draught can be regulated to suit the weight of coal burned. It is always constant, not affected in any way by the variable atmospheric conditions, and the power it uses is proportionate to the weight of coal burned.

In laying this subject of fuel economy before you, my aim has been to establish, in as simple a manner as possible, principles by which such economy can be secured, rather than deal with a mass of puzzling details of one or two isolated plants. Nothing has been advanced which cannot be adopted with but little or no expense, and to emphasise the more important items we have seen: That 200 cubic ft., or 15 lbs. of air, is the right proportion to burn 1 lb. of coal; that every pound of excess air costs approximately 1 per cent more fuel; that the ratio between the furnace area and outlet at the rear of the flues should be 2 to 1. This, in many cases, means shortening the grates by 2 ft. to 3 ft. The 4 ft. grate, fed with air and fuel in the proportion given, will evaporate as much water for 10 per cent less fuel as the 6 ft. grate will evaporate where the air supply is 25 lbs. That with a high furnace temperature and low economiser temperature the boiler is giving its maximum results, and to further add to the gain, the water should be delivered into the boiler near the bottom. There is practically no reason why the duty and efficiency of a boiler should not be as easily arrived at as the answer to a simple question in arithmetic. We all know that two and two makes four, and no reasoning can interfere with this answer. This, however, is not more certain than knowing the proportion of grate and outlet from furnace flues, the pull or draught of the chimney, the weight of the coals burned, the temperature of feed water, when we can with confidence give the duty of the boiler.

In our preliminary remarks we gave the approximate weight of coals raised, and probably 200 million tons of this is consumed in our various industries and domestic fireplaces, and a reduction of, say, 10 per cent can be effected, and personally I believe this could be exceeded, and in a way which calls, as previously mentioned, for very little outlay, if any, and this alone would mean a saving of 20 million tons of coal, besides improved health conditions for all.

Let the firemen of Great Britain once know that by their united efforts such a help could be given to the country, and I am satisfied that they, like our soldier brothers, will do all in their power in accomplishing what they knew to be their simple duty.

*(Concluded.)*

# THE CHOICE OF CONVERTING PLANT.

By F. Ashton.

It is sometimes found, when the question of electrifying industrial establishments is under consideration, that the particular kind of current that can be obtained from the supply mains is not the most suitable for the work that has to be performed, and it may be advisable in certain cases to install some form of converter. If, for instance, it is desired to run motors at more than one speed, and particularly if it is desired to vary the speed within fine limits, direct current is distinctly better than alternating current, but if no speed variation is necessary, polyphase alternating current is very suitable, especially when the machines to be driven are easily started and can be driven by simple squirrel-cage motors. There are other reasons why it may be necessary to convert one kind of current into another kind, but the writer's object is to discuss the methods of conversion rather than the conditions that render conversion necessary.

## Rectifiers.

When only a small amount of alternating current has to be converted, as, for instance, when it is desired to charge a small battery from an alternating supply, use may be made of a rectifier, such as a mercury vapour, electrolytic or mechanical rectifier. The mercury vapour rectifier, which depends for its action upon the fact that a current can only pass through mercury vapour in one direction, is now built for heavier currents than can be conveniently dealt with by other rectifiers. For charging the batteries of electric vehicles, these rectifiers are being used with marked success, and for some time past experiments have been conducted with a view to employing them in connection with electric railways. For railway work a high track pressure is advantageous, because it reduces the amount of current that has to be collected, reduces the size of the cables, reduces the pressure drop and increases the distance between feeding points. For this reason alternating-current railway systems have been designed which work at pressures as high as 11,000 and 15,000 volts. But whilst such pressures are beneficial from the point of view of transmission and distribution, direct-current motors are preferable to single-phase alternating-current motors in respect to weight, efficiency, and general operation. This has led engineers to test the possibility of converting the alternating current into direct current by means of mercury vapour rectifiers, placed upon electric locomotives so that, although high-pressure alternating current is collected from the overhead wire, low-pressure direct current is supplied to the motors. Experiments that have been conducted on these lines in America have given very promising results, and it seems that mercury vapour rectifiers will eventually be constructed for much heavier currents than those with which rectifiers commonly deal.

## Motor Generators.

If it is a question of converting current, say, for the supply of an engineering works or some other industrial establishment, there are three types of converters that may be adopted. It is difficult to put forward hard and fast rules respecting the type of machine that should be used, for much depends upon prevailing conditions, but it may be interesting and instructive briefly to consider the characteristics of each type. The oldest and simplest machine is the motor generator, consisting simply of an alternating-current motor mechanically coupled to a direct-current dynamo, each machine being totally independent so far as electrical connections are concerned. A large number of motor generators have been installed for converting alternating current into direct current and *vice versa*, and are occasionally installed now, but the motor generator's progress has of late been greatly retarded by the introduction of more efficient machines. Of the three types of converters now in general use, the motor generator is the least efficient, for it involves, as can readily be seen, a double conversion of all the energy supplied to it; that is to say, the energy put into the motor in the form of electric current is converted into mechanical energy and then back again in the dynamo to electrical energy. But as there is no electrical connection between the generator and the motor, the generator works in exactly the same way as any other generator, driven by a steam engine or other prime mover. Its voltage is determined solely by the speed and field strength. The voltage at the generator end is influenced by changes in the periodicity at the motor end, for such changes obviously affect the speed, but changes in the alternating motor voltage will not alter the dynamo voltage unless accompanied by a change in periodicity. Any desired voltage may be obtained at the direct-current end by adjusting the field rheostat, exactly as in the case of an ordinary direct-current dynamo. If the alternating-current machine be a synchronous machine having a direct-current exciter, then the motor generator is under all conditions reversible: that is to say, alternating current can be supplied to one end and direct current taken from the other or *vice versa*. But if the alternating-current machine is built on the induction motor principle, direct current can only be converted into alternating current when the alternating unit of the motor generator runs in parallel with at least one synchronous machine. If this machine be disconnected from the motor generator, the latter will at once cease to give current, for an induction motor will only act as a generator so long as it can draw its exciting current from the line. An induction or synchronous generator draws a lagging wattless current and delivers a watt or energy current to the network. Hence if it is desired to obtain alternating current from a motor generator set, the alternating unit of the machine should be of the synchronous type, unless, of course, the conditions are such that it always runs in parallel with other synchronous machinery. The advantages of the induction motor generator is that it can be started on the alternating-current side without synchronising, and owing to the slip between the revolving field and the rotor, a rise of speed in the generating station, to which the alternating-current end of the motor generator is connected, will not produce such an abrupt transformation of load from the motoring to the generating side of the machine as is experienced with a synchronous motor generator. The voltage on the direct-current side can,

of course, be regulated in exactly the same way as with a synchronous set.

### Starting Synchronous Motor Generators.

One of the objections to the ordinary synchronous motor generator is that it is not easily started on the alternating-current side, for in its usual form a synchronous motor is not a self-starting machine. It must be run up to speed by an independent motor and synchronised. In the past this frequently led to the use of induction motor generators, notwithstanding that these machines always have one undesirable effect upon the system, namely, they always tend to lower the power factor. The magnetising current which they draw from the mains is always a lagging current, irrespective of whether the alternating machine is generating or motoring. A synchronous machine, on the other hand, can be made to improve the power factor, since by over-exciting it with direct current it can be made to draw a leading alternating current which will compensate the lagging currents set up by induction motors and other inductive apparatus on other parts of the circuit. The difficulty of starting synchronous motors and the objectionable effect which large induction motors have upon the power factor of a system, have led to the introduction of what are known as self-starting synchronous motors. The rotor carries a winding similar to that of an induction motor, so that when alternating current is switched on to the stator windings, the machine runs up to speed as induction motor. As full speed is approached, however, the rotor is excited with direct current taken from a direct-current exciter or battery, with the result that the rotor pulls into synchronism and the motor becomes a synchronous machine. It acts in exactly the same way as any other synchronous motor, and if one of these machines be coupled to a direct-current dynamo a motor generator is obtained which is very flexible, although, like all other motor generators, the efficiency leaves something to be desired. It is self-starting on the alternating-current side, can be made to improve the power factor, and is reversible, irrespective of whether it runs in parallel with other synchronous machines or not. In this country these self-starting synchronous motors are not as yet widely used, but in America a fair number of frequency changers and motor generators have been equipped with them. Of course, when direct current is always available converters can be started on the direct-current side and synchronised on the alternating-current side, but as it often happens that direct current is not always available, a self-starting synchronous motor is often distinctly advantageous. Motor generators having self-starting synchronous motors, however, are more expensive than those built upon orthodox lines.

### Rotary Converters.

The machine used most commonly for the conversion of alternating current into direct current is the rotary converter, which has a very high efficiency—higher, in fact, than any other kind of converter that has been produced. On practically all the large electric railway and tramway systems these machines are utilised for converting the high-tension polyphase current into direct current supplied to the motors on the trains and tramcars. They are also employed pretty extensively in connection with large industrial establishments in which direct current is required. Not only is a rotory converter more efficient than any other converter, but it is also more simple, for it consists of nothing more than an ordinary direct-current dynamo with tappings taken from the back of the armature coils and connected to slip rings mounted on the shaft. A three-phase two-pole machine would have three tappings 120 deg. apart, and each tapping would be connected to a separate slip ring. When there are more than two poles, as is practically always the case, there are three tappings for each pair of poles, and tappings occupying like positions are connected to the same slip ring. If three-phase current be supplied to these rings, the machine runs as a synchronous motor, and it delivers direct current at the commutator, whilst if direct current be supplied to the latter the machine runs as a direct-current motor and three-phase current may be drawn from the slip rings. If the machine be driven by a steam engine or other prime mover, direct current and alternating current may be drawn from the commutator and slip rings respectively. The machine then becomes a double-current generator. Leaving aside the theory of the rotary converter and considering only its operating characteristics, it is at once obvious that there is a fixed ratio between the direct-current and alternating-current voltages. High tension polyphase current obviously cannot be supplied directly to the slip rings. Hence when the supply is a high-tension one, as it nearly always is, the pressure must be lowered by means of transformers. Transformers, however, are not always necessary with motor generators. Alternating currents up to about 6,000 volts may be supplied to the stator windings of synchronous motors. But pressures in the neighbourhood of 10,000 volts and over are not particularly safe pressures to apply to stator windings, and when the supply pressure is high, transformers may be necessary, even with motor generators. With rotary converters they are practically always necessary. Taking the transformer losses into account, however, the efficiency of a rotary converter is appreciably higher than that of a motor generator. Moreover, a rotary converter is less costly. The transformers may, of course, be placed in positions unsuitable for running machinery and economy in floor space can in this way often be secured.

### Converting Direct Current into Alternating Current.

Rotary converters are, as already indicated, reversible, although their usual function is to convert alternating current into direct current. When they are used for changing direct current into alternating current they are less satisfactory, unless the alternating end always runs in parallel with synchronous machines, for under these conditions the speed is fixed by the periodicity of the circuit; in other words, the converter operates under these conditions as a synchronous generator. But if a rotary converter be fed on the direct current side and runs independently, it runs as a direct-current motor and its speed is inversely proportional to the field strength. If the alternating current load be an inductive one, the current drawn from the slip rings lags behind the electromotive force and demagnetises the poles, and in the absence of proper precautions the armature speed is liable to attain a dangerous value. For this reason rotary converters are not as a rule used independently for converting direct current into alternating current, although they are quite satisfactory when operated in parallel with other synchronous machines. To work rotaries in this way, without other synchronous machines, it is necessary to provide an arrangement which will increase the field strength when the speed tends to rise. A method that has been adopted is to connect an induc-

tion motor to the slip rings and this induction motor drives a direct-current exciter which excites the field magnets of the converter. If the speed of the latter increases as the result of lagging currents in the mains, the induction motor's speed will, of course, rise in the same proportion. The exciting current therefore increases and compensates the demagnetising effect of the lagging currents in the armature. This arrangement, however, has not been adopted in many cases, for it involves additional complication and expense. Motor generators are, under these conditions, preferable to rotary converters because the two machines composing a motor generator set are quite independent, and lagging currents in the armature on the alternating-current side do not, of course, influence the speed in any way.

### Rotary Converter Regulation.

As there is a fixed ratio between the direct-current and alternating-current sides of a rotary converter, it is clear that the pressure on the direct-current side can only be regulated by varying the voltage at the slip rings. There are various ways of doing this. If a large variation in the pressure is desired, it is usual to connect an alternating-current booster or induction regulator in series with the transformers and slip rings, but in many instances all the regulation needed can be obtained by connecting reactance coils in the alternating-current circuit or by designing the transformers with magnetic leakage. The result in both cases is that a reactive drop is produced. But if the field strength of the rotary be increased above a certain amount, the alternating current, passing into the machine, leads with respect to the pressure, and the reactance voltage is added to that of the transformers and the pressure at the direct-current end of the machine therefore rises. If, on the other hand, the excitation is reduced below a certain value, the current, passing into the machine, lags behind the pressure and the reactance voltage is subtracted from that of the transformers. Hence the direct-current pressure is diminished. When used on traction circuits, rotary converters are compounded and the alternating current is caused, as a result of the variation in the amount of direct current passing through the series turns, to lag and lead automatically according to the amount of load. When drawing a leading current, rotary converters will, if there are induction motors running on other parts of the circuit, help to improve the power factor. Any synchronous motor may, in fact, be used for this purpose, but it must not be forgotten that leading currents like other currents heat up the windings, and when used for power factor correction as well as other work, machines must be suitably rated.

*(To be continued.)*

## BALANCED DRAUGHT AND BETTER COMBUSTION.*

One of the greatest steps in recent years for making better combustion is the invention of Embury McLean for the automatic maintenance of a constant pressure in the furnace of steam boilers. The novelty of the idea consists in the application of a regulator controlling the movement of air and gases, the operation of which originates at the fire or furnace chamber.

The value of this invention can perhaps be more readily grasped if we consider its function as similar to the governor of an engine. The duty of the engine governor is to maintain a constant speed, while the balanced draught maintains a constant furnace pressure. Although governors are regarded as necessary, their use does not imply any criticism of the efficiency and general workmanship of the make of turbine or engine. In the same way an appliance to provide a constant regulation of the furnace fire, while of similar great importance, accords full recognition to the merits of good design in the boilers, stokers or grates. This fact is already established by the largest builders of boilers and stokers themselves, in recommending the system to their customers, because it eliminates the deterrent elements that tend to spoil the best performance.

For several years the writer was interested in the installation of mechanical draught equipments, both forced and induced. Experience with both types tended to his preference for using solely the induced draught, which he advocated with the illustration that draught is like a string, you can pull it better than you can push it. This citation seemed to meet general concurrence with his clients until he met a wise one, who shook his head in dissent. This man said it depended on how you regard the function of the gases, whether they are to impart heat by thorough contact with the boiler tubes, or are merely to be carried into the atmosphere. The author realised at once the value of this presentation of the matter. Nevertheless, the forced draught was attended with so many serious objections from an operating standpoint, that we continued for a long time to favour the induced draught.

Briefly stating these objections to the use of forced draught, the chief one was the tendency of the air to seek the paths of least resistance through the fuel bed, producing, under rising pressure, blow-pipe flame jets against local parts of the boiler surface with great detriment to same until the effect ceased by the formation of an open hole, which then permitted the free passage of cold air, that also reduced the efficiency. Our other objections were due to the high maintenance cost caused by the forced draught blast for repairs on the boilers, as well as on the doors and front and on the masonry. Then, too, with stokers the forced draught would often cause the fire to burn back into the hoppers and injure their drive. There were other objections from a utilitarian standpoint in the difficulty of keeping good help where forced draught was employed, as well as the usual dirty and sorry condition of the boiler-room where it was used.

### Tendency towards Bigger Boilers.

For these reasons, the writer hesitated to recommend the forced draught to his clients for many years. Modern conditions, however, were compelling its use because boiler units were becoming bigger, by reason of larger sizes reducing the horse-power cost, as well as the saving by such units of room space and piping. For the same reasons, there was a gain in being able to get a higher duty than the normal rating whenever needed without capital investment for idle boilers, all of which influences were impelling owners to adopt forced draught under their grates or with their stokers.

A suction draught to produce the necessary combustion to give similar results would require either extremely high chimneys or such powerful induced draught fans as would whirl the gases through and out without sufficient time for proper contact with the heating surfaces.

* By H. J. Brinckerhoof, of the Engineer Co., New York.

Nevertheless, the disadvantages of using forced draught that have been enumerated continued to exist and were augmented by the increasing pressures being employed.

It is hard for some to realise what an immense step the McLean invention makes in the development of modern practice. The invention on which the basic patents were granted was originally worked out by various means of mechanically connecting the forced draught and the flue damper to obtain their simultaneous control; and while the courts have construed the McLean patents to be sufficiently broad to cover all such means, it was not, however, until the present regulator having its movement initiate directly at the furnace was brought out, that the remarkably perfect results now obtained were possible.

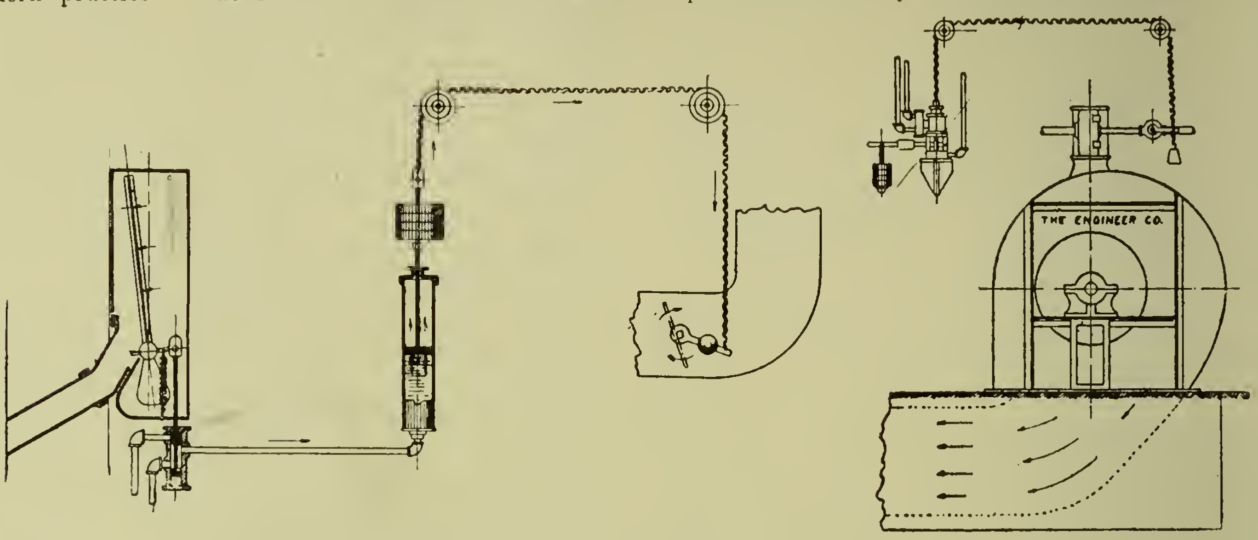



Fig. 1.—Balanced Draft Regulator, Damper moved toward closed position.

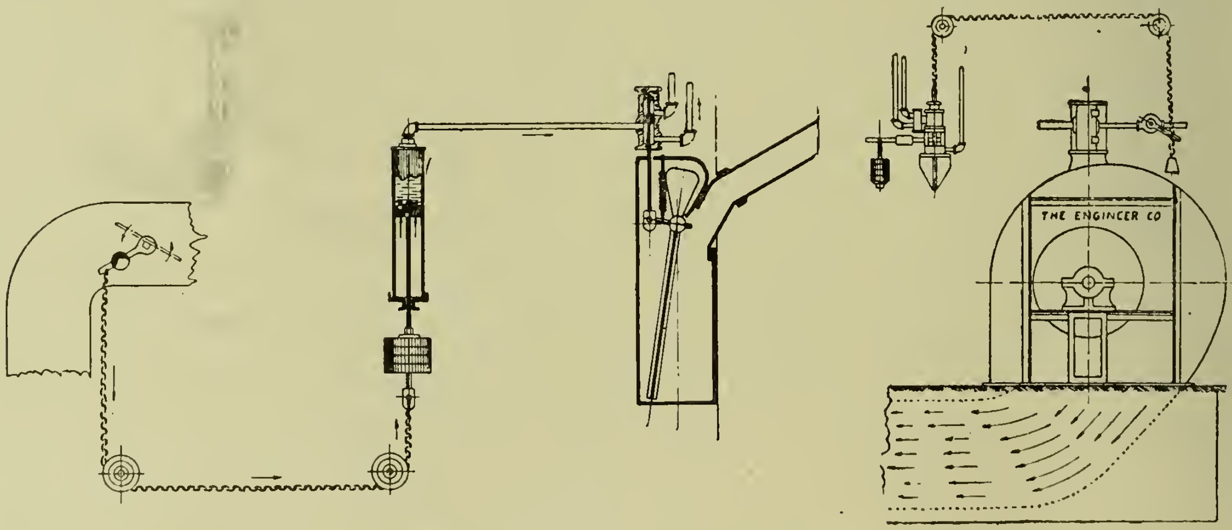



Fig. 2.—Balanced Draft Regulator, Damper moved toward open position.

## Regulator is Simple.

This latest development cannot be considered complicated. The regulator is simplicity itself, as there are only two moving parts, a swinging plate and a pilot valve. A large plate of asbestos set in an iron frame, with a weight at its lower edge, is pivoted on an axis through its centre of gravity so that its weight does not affect its movement. It will therefore remain stationary in any position if the pressure on its two sides is the same.

The pressure of the furnace gases is transmitted through a cast-iron duct to one side of the plate and acts against the pressure exerted by the atmosphere and the tension of a small spring on the other side. The movement of the plate actuates a small pilot valve admitting water to a hydraulic cylinder, the piston of which moves the individual outlet flue damper of the boiler. Should the suction or minus pressure in the furnace become greater than was predetermined to best suit the conditions of the particular boiler, this plate will be drawn inward and the damper will be moved toward its closed position, as shown at Fig. 1, until the suction is reduced to a point where the plate is again in a balanced condition, and as the pilot valve is then closed, the damper remains stationary in that position.

Or *vice versa*, should the suction or minus pressure become less than the predetermined pressure, when the blower speeds up or for any other reason, the plate would swing outward, thereby operating the pilot valve so that the damper would be moved towards its open position,

shown at Fig. 2, until the balanced condition is again attained and the pilot valve closes, holding the damper in this position until there is another change of pressure of the furnace gases. By adjusting the tension of the spring, any desired suction or minus pressure may be accurately maintained in the furnace.

Following Mr. McLean's lead, many have endeavoured by hand adjustment of their outlet and inlet pressures to produce synchronously a balanced or neutral draught in the furnace. It may be true that this can be done temporarily, the same as an engineer can adjust an engine at throttle and cut-off to run at a constant speed without the governor, but it will not continue to do so automatically when the conditions vary.

Where a number of boilers are connected by a flue main to a chimney, the pull will be different to each boiler, and where connected to a common air duct from a forced draught fan, the supply and pressure will also vary to the individual boiler. Hence it would require an individual stack and fan for each boiler, with constant adjustment by hand, to suit the changes in the load and the atmospheric conditions to approach the same results as the McLean invention.

### Advantages of Balanced Draught.

A uniform balanced draught in the furnace of each boiler is accomplished and maintained by operating only the needed movement to restore the equilibrium and adapts itself automatically to produce any rate of combustion the load requires, where $CO_2$ records are kept in plants having the system, the percentage runs high and remains very uniform. Without automatic furnace control, an inferior class of men in the boiler-room are struggling to do with the boilers what the engineer would not attempt on his engine.

The balanced swing plate controlling the system is usually set so it will not act on the suction or chimney draught until it exceeds 0·03 to 0·06 inches and maintains this stable condition in the furnace. This result is accomplished by adjustment of the tension spring to partially overcome the pressure of the atmosphere, and when once set to suit conditions, the proper action continues indefinitely. The effect of this slight offset from the atmospheric balance insures that the heat of the fire will always be drawn gently away from the boiler front, the advantage of which is readily understood. The almost neutral pressure thus maintained guards against losses from any inrush of cold air whenever the doors are open or through leaky cracks in settings or around the cleanouts.

The more important object of the invention, however, is to maintain perfect combustion under any condition of load and move the undiluted heat forward in contact with the entire heating surface efficiently and without harmful effect.

The balance draught system operated and controlled from the furnace, as invented by Mr. McLean, was designed to work with a moderate chimney draught in connection with a positive air supply. It enables owners to burn any grade of fuel, and to get the utmost duty from their boilers with comfort and economy. It is adapted to hand-fired boilers as well as stoker-fired, with no radical change in the settings or fronts in either case. The adoption of the system has been remarkable and proves it to be thoroughly practical, and it would seem that balanced draught controllers are likely to become as commonplace on boilers as governors are on engines.

## PETROL STORAGE.

### Messrs. Braby & Company's System.

In a recent issue we described a modern system of storing and measuring petrol in bulk which presented a number of novel features. Our object in returning to the subject is to deal with another system, which, like that previously described, is British throughout—in design and manufacture. The makers are Messrs. F. Braby and Co. Ltd., of Deptford and London, who have developed four distinct types to suit the varied requirements of large and small garages. These differ only in the method employed for drawing off and measuring the motor spirit, many of the features being common to all types. For example, each type involves the use of an underground tank, filling nozzle and filter, the Company's patented "Petrolvent," which is designed to prevent evaporation and to act as an additional safeguard

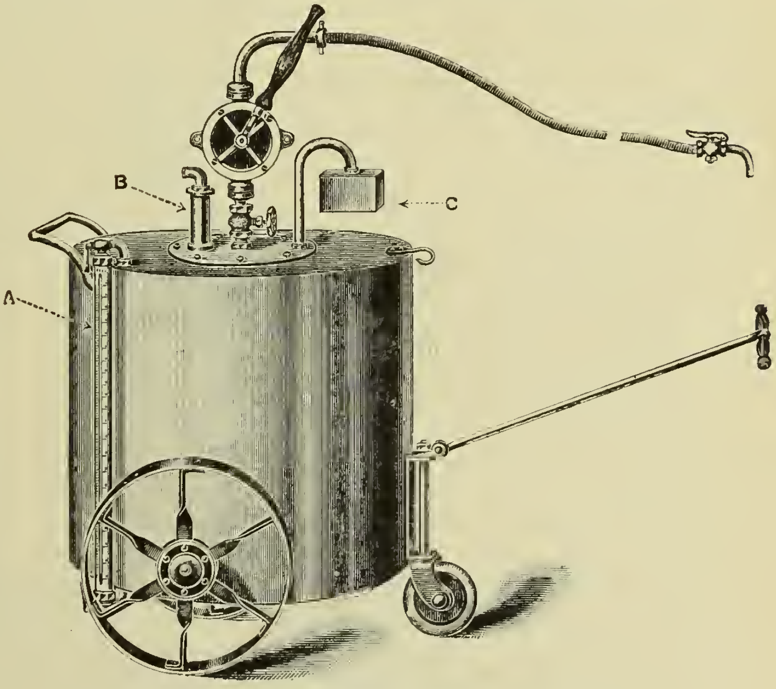



Fig. 2.—Portable Storage Plant, having a capacity of 50 gallons.
A—Gauge Glass Contents Indicator. B—Filling Filter.
C—Patent "Petrolvent."

against fire and explosion. It is a welded double-valve box, by means of which the vent pipe is normally closed to the atmosphere, but which allows of the inlet and egress of air when petrol is being drawn from or run into the tank.

It will be seen from the diagram (Fig. 1) that the spirit is raised from the underground tank by means of a semi-rotary hand pump to a galvanised welded-steel cylinder, which is fitted with a protected gauge-glass and scale calibrated in gallons or parts of a gallon. When this cylinder has been filled to some predetermined measure, any surplus petrol returns automatically through the overflow pipe to the storage tank, thus facilitating the measurement.

The filtered petrol is drawn off in measured quantities through a special wire-bound petrol-resisting hose, and, to meet the requirements of the public authorities, any petrol remaining in the cylinder pipes after charging the vehicles is readily returned to the underground stor-

age tank. Both the pump and the filling nozzle are securely locked to prevent them from being manipulated by unauthorised persons. The contents of the storage tank can be ascertained at any time, either by means of a graduated dipping rod, or, more simply, by glancing at the protected tubular contents indicator, which can be specially provided.

Messrs. Braby have also designed a portable appliance (shown in Fig. 2) consisting of a galvanised welded tank with baffle plates, mounted on wheels, and fitted with glass gauge, filling filter, patent "Petrolvent," semi-rotary pump, wheel-valve, and wire-bound petrol-resisting hose—terminating in a copper bend. The capacity of the tank is 50 gallons; the use of these very handy "portables" saves considerable time, as they can be rapidly filled with petrol and wheeled to the standing vehicles, thus enabling them to get away without delay.

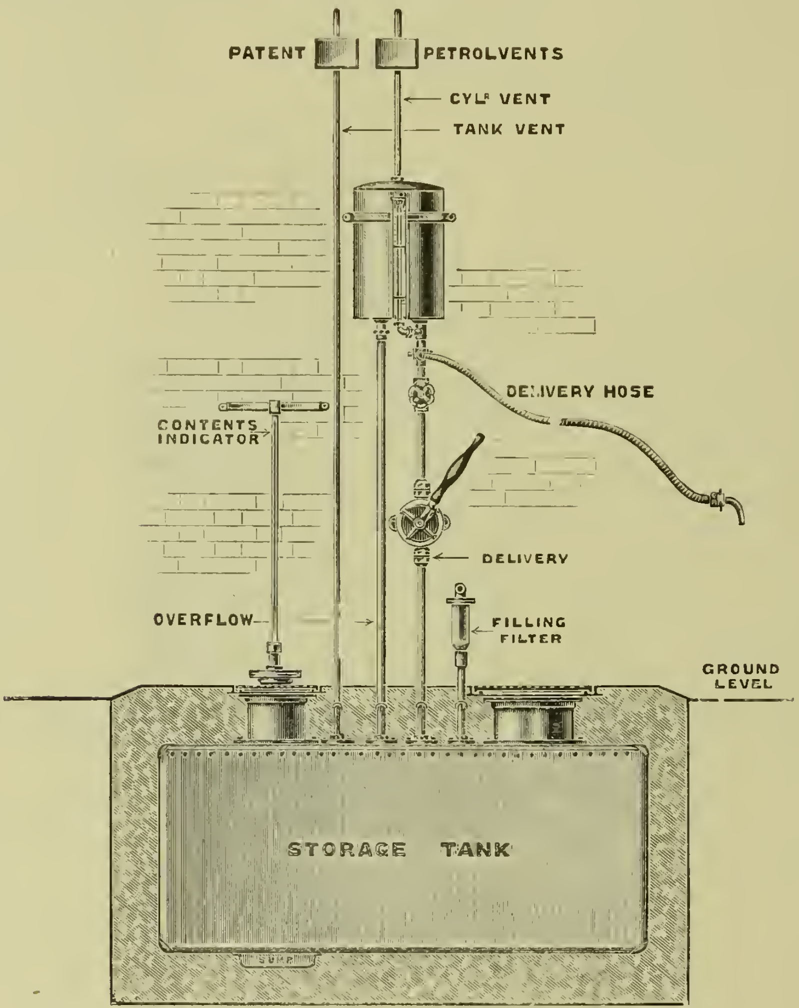
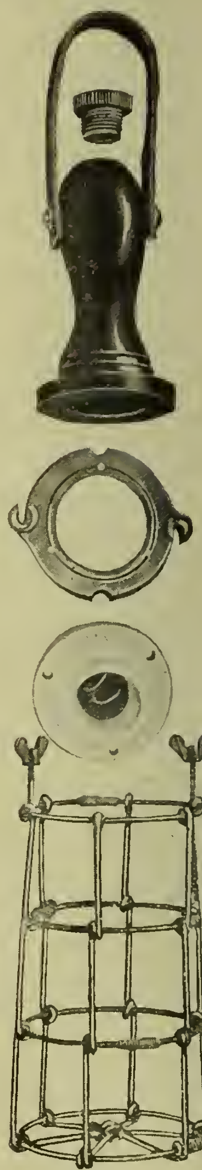



Fig. 1.— General arrangement of Type "A" Plant, manufactured by Messrs. F. Braby & Co. Ltd., showing concrete setting of tank and deep sump.

As to the general question of the employ of petrol-storage plant, one or two observations may be permitted. The waste in oil and petrol that occurs is almost incredible, and it may be truly said that most of this waste is preventible, simply by the adoption of proper storage plant, such as we have described. The matter concern very particularly the owners of industrial motor vehicles, and it must be properly attended to if efficiency is to be obtained. In considering the outlay on the plant it should not be overlooked that where petrol is already stored in tins on a fairly large scale the idle capital represented by the deposits on two-gallon cans will go a long way towards the cost of a bulk storage plant on the system now described. In such cases also, the clerical work of keeping account of the cans and booking them in and out is all obviated by the storing in bulk, with corresponding saving in time and trouble. Why, even the recovery of liquid which is lost through the improper emptying of tins, and the avoidance of evaporation from tins, represents a very substantial proportion of the first cost of the storage plant. Moreover, by the use of the latter, fire risk is greatly reduced, time is saved, and the filling of the tanks on the vehicles is greatly facilitated.



B.T.H. Hand Lamp dissembled.

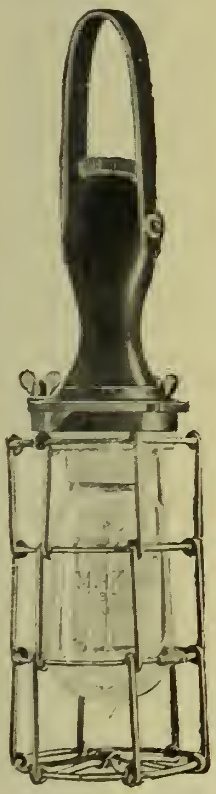
## THE B.T.H. HAND LAMP.

[Messrs. The British Thomson-Houston Co. Ltd., Rugby.]

These lamps, which are primarily intended for workshop and factory use, are strongly made to withstand rough handling, and embody certain improved features which are not possessed by others now on the market.

Each lamp consists essentially of three parts; a handle, a holder, and a guard. The handle is made of ebonised wood, and furnished at the top with a rubber ring and insulated bush through which the flexible cord enters. It is further provided with a leather strap or handle securely attached by means of brass screws of such length as to prevent the possibility of their entering the wire-way in the centre of handle.

The holder is constructed entirely of porcelain (apart from the plungers), and is provided with a flange whereby it is attached to the handle. This attachment is effected by screws which pass through the flange of the lampholder, through a wooden flange at the end of the handle, and into a metal ring slipped over the latter. The attachment is therefore not dependent on wood screws fixed in the end grain of the wood. The holder is provided with a skirt so



The New B.T.H. Hand Lamp.


B.T.H. Hand Lamp with wire cover removed.

as entirely to cover the cap of the lamp, and is so designed as to permit of easy wiring when unmounted.

The guard consists of strong galvanised iron wire made up in the form shown in the illustrations and is secured to the handle by two brass wing nuts. The attachment is made through two slots in the periphery of the metal ring referred to above, and so contrived that by slackening the wing nuts a couple of turns the guard can be disengaged by rotating it about the axis of the lamp. The size of the guard is large enough to accommodate any lamp up to and including 60-watt standard Mazda.

This hand lamp, which passes Home Office requirements, has been designed to meet the urgent need of a reliable hand lamp for factory use. Both electrically and mechanically this lamp is considerably ahead of other hand lamps at present on the market, and is confidently recommended. It is entirely of British design and made at the works at Rugby, England.

## THE QUALITY AND SCOPE OF SHAFTING BEARINGS.

By F. R. Parsons.

The continuously-increasing cost of all non-ferrous metals is beginning to make its influence felt in the quality and length of life of bearing metals, particularly those peculiarly adapted for sustaining shafting, and in the use of machine tools. This is much to be deplored, for at its best, and in these days when durability was more a consideration in determining the composition and character of the various alloys for given duties, the limitations of shaft bearings oftentimes fell notoriously short of reasonable expectations. How, then, can we to-day hope to reach even the outermost fringe of those by-gone limitations when quality is recognisedly and even studiously subordinated to cheapness of production.

Years ago, progress was defined as being the result of an assiduous endeavour to resist wear. To-day, we live in an age with a world always in desperate hurry to complete what is never properly begun. We sacrifice quality for cheapness, because we have grown to think that beyond our lifetime, and the war, there is little that really matters. To-day, the analytical chemist is being elbowed out by the mechanician, and his laboratory handed over to the latter to make room for the instalment of rapid-production machinery.

A few months ago the present writer was called in to advise with a view to correcting the inefficient and unsatisfactory running of a 10 effective horse-power gas installation, driving a laundry. The main shafting, of 2 in. diameter, running through the length of the building perhaps 80 feet, was carried in cast-iron J-hangers, provided with so-called gun-metal bearings. The whole of the plant had been fixed some two years previous by a reputable firm of engineers, the material—machines, shafting, pulleys, hangers, etc.—being factored by an engineer whose services had been retained by the laundry company. Now, under circumstances usually met with in laundry work one would not, naturally, expect to find a superabundance of floating dust particles present in the air, and this case was no exception, since the boiler, supplying steam to the washing machines, etc., was situated in an altogether separate building. Yet this was the theory advanced by the aforementioned engineer to account for the shafting wearing completely through some of the brass bearings in the hangers. Possibly, seeing that the charge could not very well be attributed to inefficient or insufficient lubrication, since each bearing had been provided with automatic spring lubricators of very effective form—what irony!—no other probable reason occurred to the intelligence of this particular individual.

An examination, however, made by the writer, revealed two separate and distinct causes that would account for the abnormal wear. Firstly, the original diameter of the bearings had been two inches, their length was exactly $\frac{1}{4}$ in. longer than this; or, in other words, less than $1\frac{1}{4}$ times their diameter. Secondly, the wear had not been wholly of a cutting or wearing nature, as would be the case if it had been due to a lack of lubrication, or misalignment, but in nearly every case the surface metal had been forced outwards until it had formed on each side of the lower half of the bearing a projecting fin; showing unmistakably that the composition of the metal was of very inferior quality.

In this connection a very curious phase of the question came to light. One bearing, that nearest the pulley driv

ing the largest machine, was most unaccountably in good condition; the wear in this being nothing but what would be expected after two years' running. The writer, although assured that nothing had been done to it in the way of repairs since the plant was installed, was nothing if not curious as to why this particular example differed from the rest to such an extent. Subsequent inquiries, however, revealed the cause. One of the fitters employed by the firm who erected the plant had accidentally dropped a pair of the brasses down the well, and not being able to recover them his firm had had to replace them.

Now, in the writer's opinion, it would not have been unreasonable, had it been possible, to have compelled the firm that manufactured these bearings to have supplied free of charge others of a length not less than three diameters in length, and of a composition that should bear a period guarantee, and stand an analytical test; in addition to which to pay all charges incurred, and indemnify the owners against resultant loss and delay. As for an engineer who would permit such bearings to be erected, knowing their duties, the least than can be said is that he is not worthy the title he bears, and, moreover, is a disgrace to his profession.

Let us now see wherein these bearings so lamentably failed, and why it is false economy to purchase nothing but the best and most proved alloy when bearings of this description are required. Unfortunately, anything can be termed "gun-metal," if it can be made to pass for such, without having to bear the hall-mark of genuineness, and the layman can be quite easily gulled into a belief that he is purchasing a specially high-quality, wear-resisting alloy when he is only paying extortionately for a big proportion of zinc, or perhaps lead. But an engineer should not be so easily befooled, and one who knows his business would not only insist upon a mixture certificate, but if he had any reasons for questioning the quality of material used in the bearings, or its composition, he would also insist upon being provided with test pieces, in order to ascertain its ultimate strength and percentage of elongation.

Of course, this has reference to cases wherein the fulfilment of a contract carries high obligations, or in the event of a specific order being expected to fulfil a maximum duty.

In the first place, the bearings in question failed because of inferior design—the pressure per square inch on them being much in excess of what they were capable of bearing. Unless, under very exceptional circumstances, or in the event of a bearing being required to carry a load imposed upon it by the shafting alone, is it advisable to reduce their effective length below two diameters; and in cases where they have to carry a friction load, only limited by the strength of the shafting, then a bearing, if of gun-metal, or any similar alloy, needs to be 3½ to 4 diameters in length. Lubrication cannot perfectly be effected unless ample length is allowed, for the pressure per square inch is too great to preserve intact the oil film upon which the shaft revolves, with the consequence that it is squeezed out.

The bearings also failed because the quality of metal was inferior. A good quality bearing metal should show no signs of spewing out under pressure, otherwise it would be indicative of too soft an alloy. On the other hand, there is a limit beyond which it is unnecessary to go. For instance, there is no need to employ a mixture having a greater proportion of copper than is necessary to ensure against undue wear, otherwise their cost goes up unnecessarily. For shafting bearings performing ordinary duties the writer has found that excellent, and in every way satisfactory results are obtained if the mixture comprises copper 16, tin 2½, zinc ½. For bearings required for machinery, and the writer has used this mixture in the production of bearings for lathes, and for capstan bushes, nothing better is obtainable than a proportion of copper 9, tin 1, zinc ½.

Phosphor-bronzes of high phosphorus content, by reason of their possessing low-friction coefficients, and having power to resist abrasion, make an ideal alloy for use in circumstances when it has been effectively demonstrated that ordinary mixtures, by reason of the high duties imposed upon them, have signally failed. Such a case may be cited by the writer.

Some seven or eight years ago he was consulted by a factory owner as to the cause that led to a continued state of trouble with the crank-pin bearing of a 75 H.P. condensing engine. A year or two previous the engine referred to had been modified and altered, the cylinder bored, a condenser added, more modern valve gear fitted, and speeded up, thus increasing its power output from 40 to 75 H.P. The increased duties put upon it showed itself at the crank-pin bearing, this being called upon to stand an increase in pressure of over 80 per cent. The increasing of the crank-pin in diameter and length, and the provision of a larger big end and bearing being a costly job, the writer decided upon trying a phosphor-bronze bearing in lieu of the ordinary alloys of gun-metal previously used. He stipulated for a mixture composed of: Copper, 92 per cent; tin, 7 per cent; phosphorus, 1 per cent. The bearings were so made, fitted and fixed, and the only attention they have received during the seven or eight years has been a periodical taking-up, perhaps three times a year.

## STEAM BOILER EXAMINATIONS.

By Edward Ingham.

According to the Factory and Workshop Act of 1901, "every steam boiler must be examined thoroughly by some competent person at least once in very fourteen months," the object of such examination being to ascertain whether or not the boiler is in safe and satisfactory working condition.

All types of boiler are liable to defects, and it is the duty of those who make the examinations to discover these defects, so that danger in working may be avoided.

Now whilst some defects are easily discovered, others are very liable to escape detection, especially those existing in boilers which are more or less inaccessible. In this article, it is proposed to discuss more particularly these latter defects and to point out some of the means employed for discovering them.

Let us consider first the type of internal corrosion known as "smooth" wasting. This is a particularly dangerous form of corrosion, because the remaining surface of plates presents a smooth and even appearance and is consequently very liable to be mistaken for the orignal surface. To detect this form of wasting, a careful examination of the overlaps of the seams and the rivet heads should be made, when it will be noted that the surface of the plate directly under the rivet heads stands up above the general surface of plate.

If it be suspected that a plate is corroded to any serious extent, the safest plan is to drill a small hole through the wasted portion so that the remaining thickness of metal may be correctly ascertained: care should, of course, be taken to remove the "burr" left by the drilling before gauging the thickness. Hammer testing,

when judiciously carried out, will frequently be found very useful in discovering seriously wasted plates. After a little practice with the hammer, a plate which is deeply wasted over a considerable area may be readily discovered by the characteristic sound which is emitted on hammering the plate, and by the "feel" or "yield" of the plate. In many instances, plates have been corroded to such an extent that the blow of the hammer has resulted in breaking through the plate. Hammer testing should always be regarded as a recognised part of steam boiler "thorough" examinations. A number of explosions have occurred through failure to discover deeply-wasted plates, which would no doubt have been discovered by the proper use of the hammer. The hammer heads used for this purpose should be rounded at one end and chisel-shaped at the other. The rounded end may then be vigorously applied without fear of seriously indenting the plates, whilst the other end may be usefully employed for removing scale from seams, etc., and so facilitating the examinations.

Another very dangerous defect is fine grooving. This defect is most commonly met with in the barrels of loco'-type boilers, the longitudinal seams of which are lap-jointed. In a lap-jointed boiler the shell is not truly circular, but the internal pressure is constantly tending to make it so. This results in constant straining at the joint, and eventually the skin of the metal is broken and a fine hair-like groove is produced. In the majority of cases the groove takes a rounded form, owing to the corrosive action of the feed-water, but where the water is pure, the fine hair-like groove is met with. In modern boilers butt joints are used instead of lap joints, so that the shell remains truly cylindrical, and the tendency to straining and grooving is thus avoided. It is a difficult matter to estimate to what depth fine grooving exists and whenever the defect is met with, therefore, it is advisable to have a hole drilled, when the depth can be properly ascertained.

Fractures at seams and in the solid plate are occasionally met with in various types of boilers, and are, as a rule, dangerous defects, somewhat liable to escape detection. This is particularly the case with what is known as the "lap-joint" fracture, which is occasionally met with in old lap-jointed boilers. There is probably no more dangerous defect than this, because it lies hidden under the joint, where it cannot possibly be seen, unless it extends beyond the edge of the overlapping plate, or is so deep as to actually perforate the plate. The defect is only likely to be introduced during construction, in second-rate boiler shops where there are no means of rolling the plates right up to their edges, and where, in consequence, the flats left are hammered to the required radius by means of hammers. The straining caused by the boiler not being truly cylindrical tends to aggravate the defect.

The existence of fractures in boiler plates is frequently indicated by leakage, but not always. The only satisfactory method of discovering these defects is to cut out some of the rivets and separate the plates, but such a proceeding is, of course, troublesome and costly. Fortunately, lap-joint fractures are nowadays rarely met with, as modern boilers are constructed with butt joints, whilst plates can be satisfactorily rolled right up to their edges so as to require no treatment for bringing them to the desired radius.

In some types of boilers it is impossible to see the condition of the greater portion of the internal parts, and in such cases other means of ascertaining the condition of the boilers than visual inspection have to be resorted to.

Thus locomotive boilers, portables, and many vertical boilers are all more or less inaccessible, whilst the tubes of water-tube boilers and superheaters and the vertical pipes of fuel economisers are almost wholly inaccessible internally.

Consider the case of a locomotive boiler. Generally speaking, the only internal parts of this type of boiler which are open to visual inspection are those which can be seen through the manhole and the mudhole, and through the sightholes specially provided for the purpose, and consequently other means must be adopted to ascertain the internal condition. In connection with boilers of this type, hammer testing furnishes a great deal of valuable information in regard to existing defects. Grooving, for instance, which occurs in various parts, but more particularly at the bottom of the narrow water spaces, may frequently be discovered by such testing, but in order to ascertain the depth of the grooving it would be necessary to drill a hole through the grooved part. Fractured and grooved screwed stays may also be discovered by being struck with a hammer at one end, whilst another hammer is held at the other end. The best way, however, of detecting broken stays is by drilling a small hole through the centre of the stays, when fracture will be at once indicated by leakage. Sometimes grooving either of the plates or the stays may be found by inserting the hand through the hand-holes and feeling with the fingers. In fact, the sense of touch ought to be regarded as an essential part of steam boiler inspection.

For examining stays in narrow water spaces, a mirror, used in conjunction with a lighted candle, will often be found of great use.

The foregoing remarks apply also for the most part to boilers of the vertical type.

In locomotive-type boilers wasting of the smoke tubes both on the fire side and the water side is a common defect. Wasting on the fire side is usually most severe just beyond the ferrules at the firebox end, and is caused mostly by the scouring action of the particles of fuel carried along with the products of combustion. Such wasting may be tested by means of prodding tools, which should preferably be attached to the ends of wooden shafts and used as levers. It is not advisable to use long iron bars for this purpose, because it is possible with these to break through really good tubes owing to the great force which may be applied by such means. A wooden shaft will "spring" or "give" and so form a safeguard against the use of undue force.

The only satisfactory method of ascertaining the condition of the water side of those smoke tubes which are inaccessible is by withdrawing them occasionally. Where it is not possible to withdraw all the tubes, a good idea of the general condition may be obtained by withdrawing a tube here and there and making an examination of those that are removed.

In water-tube boilers, the tubes themselves are the parts which are liable to suffer most from the effects of "wear and tear," because the bulk of the work of evaporation is done in them. In fact, most of the failures and mishaps which occur in connection with the working of boilers of this class are caused through defective tubes, which are liable to suffer from both internal and external corrosion. Hence the tubes require carefully examining at regular intervals, but, unfortunately, owing to their small diameter and their comparatively great length, satisfactory internal examination cannot

be made. The best way of detecting internal wasting is to pass a small lamp through the tubes. Electric lamps sufficiently small to allow of their being passed through the tubes have been specially designed for this purpose. Some idea as to the extent to which external wasting has taken place may be obtained by calipering the tubes at several places.

Fuel economisers which, like steam boilers, require periodical examination, are very difficult to thoroughly examine owing to their inaccessibility. Not only is it impossible to view the interior of the vertical cast-iron pipes properly, but the exterior of the greater portion of the pipes cannot be seen.

Internally, the pipes may be best examined by dropping a lighted candle down into them, or else an electric lamp, as in the case of the tubes of water-tube boilers. As regards external wasting of economiser pipes, calipering the external diameter of the pipes will prove useful. Cast iron, it must be remembered, is not altogether a suitable material for resisting steam and water pressure, and when economiser pipes made of this material become wasted both internally and externally, it cannot be a matter of great surprise if fracture should occur. Scale on the interior surfaces of the tubes and internal stresses in the metal introduced during manufacture tend to increase the risk of fracture. The presence of scale, of course, offers restraint to the free expansion of the pipes and so throws more or less severe stresses on the metal. It is obvious, therefore, that whenever much wasting is suspected, it is very necessary to ascertain the actual remaining thickness of metal. Drilling is usually the most reliable method of ascertaining the thickness of wasted boiler plates, but as regards wasted pipes of economisers it is not so reliable, for the following reasons: In the manufacture of the pipes, irregularities in casting are always liable to occur; thus, if the cores are not truly central, the metal will be thicker on one side than the other, and if a hole be drilled through the thicker portion mistaken ideas as to the actual remaining strength of the pipes will be obtained. Again, misleading dimensions as to the actual thicknesses of metal remaining are liable to be obtained, because the wasted metal is frequently changed into oxide which is so like the metal in appearance, and which clings so closely and tenaciously that it is a most difficult matter to decide from examination through a drilled hole which is oxide and which metal. A better method of ascertaining the thickness, and, in fact, the only really reliable method is to withdraw and break up certain of the pipes, and where serious reduction in the thickness is suspected, this course should really be adopted. It is, of course, only necessary to withdraw a pipe here and there, as this will usually be sufficient to give a good idea as to what is the general condition of the pipes.

The hammer test may, of course, be applied with advantage to the examination of economiser pipes. Fractured pipes are frequently discovered by the sound they give on being struck with a hammer.

So far no mention has been made of hydraulic testing. In all cases of boilers, economisers, superheaters, etc., which are not open to thorough inspection, it is advisable to apply a hydraulic test with a view to discovering weak parts, defects, etc. Many engineers do not place much reliance on the hydraulic test, whilst some believe it to be distinctly harmful owing to the fact that there is always the possibility of defects being aggravated by it without their existence being revealed. Cases have indeed been recorded of vessels failing under steam shortly after having been hydraulically tested, although no signs of weakness were discovered at the test. Nevertheless, such cases are rare, and provided the test is carried out properly, and under the supervision of an expert, there can be no doubt that it is, generally speaking, extremely valuable in revealing defects which would otherwise escape detection.

## FUSIBLE PLUG DANGERS.

By Edward Ingham.

Most steam users nowadays realise the importance of fitting fusible plugs into the furnace crown plates of their boilers in order to guard against serious overheating, bulging, and collapse of the plates caused by shortness of water or by the presence of impurities in the feed water, such as the flour-like carbonates of lime and magnesia, and grease.

It is also generally recognised that a fusible plug, to be reliable, must be something more than a mere plug of fusible metal, such as lead, screwed into the furnace crown plates. Experience has shown that such plugs not only become very seriously affected by continued exposure to the furnace gases, so that the temperature at which they will fuse is considerably altered from the fusing temperature of the original metal, but even should the metal remain unaffected, the plug often only partially melts (even when the plates are overheated, to a dangerous extent), thus allowing only an insignificant jet of steam to escape, which tends to prevent further melting and which is quite useless for putting out the fire and preventing distortion and perhaps collapse of the plates. As a matter of fact, a number of collapses and explosions, involving loss of life, have occurred with boilers fitted with these simple plugs.

The best and most modern fusible plugs, such as those made by the National and the Vulcan Boiler Insurance Companies, consist of an outer casing or body of infusible metal, such as gunmetal, the fusible alloy itself, and a central plug of infusible metal, which is embedded in an annulus of the fusible metal. With such an arrangement, when the fusible metal melts, the central plug is entirely blown out, and a clear opening is thus provided, through which the steam and water in the boiler may escape in sufficiently large volume to quench the fire and to give an alarm to the fireman.

Since all fusible metals are liable to be affected by the heat of the furnace gases, and also perhaps by the chemical action of the boiler feed water, precautions are taken to protect the metal, as far as possible, from the gases and the water. Thus, the metal on the fire side of the plug is protected by means of what is termed a "protector flange," which consists merely of a small flange or lip provided on the central plug of infusible metal, and which laps over and completely covers the surface of the fusible alloy, which would otherwise be exposed to the hot gases. This protector flange, in addition to protecting the alloy, serves another useful purpose, inasmuch as it prevents the alloy from gradually dribbling or "wearing" away as time goes on, which would otherwise be very liable to occur.

As regards the fusible metal on the water side of the plug, it is not quite so necessary to shield this as it is the portion of the alloy exposed to the gases, but in the best designs the actual surface exposed is extremely small, and is, in fact, only a narrow circular ring.

Now although steam users are generally alive to the importance of fitting into their boilers only fusible plugs of the most approved design, many do not appear to realise that there is such a thing as keeping a good article in good condition. Fusible plugs of the best designs are frequently condemned as being useless or unreliable, owing to their failure to act at the critical moment, or perhaps to premature fusing, but the fault is generally the user's, not the designer's.

As a matter of fact, a good plug will rarely fail if two important conditions be complied with. The first of these is that the plug be kept quite clean both on the fire side and the water side; the second is that the fusible alloy be changed at intervals of eighteen months or two years.

With regard to the first condition, if the plug be not cleaned at sufficiently short intervals, soot and dirt will become caked hard on the fire side, whilst scale and deposit will collect on the water side.

In the former case, it should be obvious that the hard soot and dirt on the fire side will tend to prevent the central plug of infusible metal from being blown out when the alloy melts as a result of overheating of the furnace crown plates. Although the pressure acts downwards, tending to blow out this central plug, the force available is only small, owing to the small effective area acted upon, and may be altogether too small to overcome the resistance offered by the soot and dirt.

If scale and deposit be allowed to crust on the water side of the plug, there will be a tendency for overheating of the plug to occur, so that the fusible alloy may melt even when there is an ample supply of water in the boiler and the water is not thickened by grease, etc.

It is important therefore that all fusible plugs be cleaned thoroughly, *i.e.*, scraped bright, at fairly frequent intervals.

So far as renewal of the fusible metal is concerned, this is often considered to be quite unnecessary, and for this reason the advice of the makers of the plugs to have this done at intervals not exceeding eighteen months or two years is not uncommonly ignored. This is a great mistake, because, as already pointed out, all fusible alloys become affected after continued exposure to the heat in a boiler furnace, so that instead of fusing at the desired temperature, they may not fuse until such a high temperature is reached as will injure the boiler plates.

The best plugs are, of course, designed in such a manner that the renewal of the alloy may be effected simply by unscrewing a central cap (which contains the alloy and the central infusible plug), and replacing this by a spare one.

We have seen that in modern plugs special provision is made to ensure that a clear and effective opening will be made for the escape of the hot water and steam when fusing occurs.

Now whilst, on the one hand, it is most important to avoid small openings, it is on the other hand, perhaps, equally important that the openings should not be unduly large.

When the openings are unduly large, there is a danger that the quantity of steam and water discharged when the plug melts out may be so great as to cause serious injury to the fireman by scalding. Accidents of this nature have indeed occurred, and we have in mind one which occurred a few years ago at a small works in Manchester.

In this instance the fusible plug, fitted into the crown of a vertical boiler, fused as a result of overheating. The opening provided was so great, viz., 1 in. diameter, that the steam and water escaped in such volume as to scald three men very severely, one of whom subsequently died.

The Board of Trade, at the formal investigation which was afterwards made into the cause of the accident, made the following remarks in reference to the size of the opening in the plug:—

"Unhappily, the orifice created was of so great an area as to allow an unnecessarily large quantity of steam to escape. Had the orifice been ½ in. diameter instead of 1 in., only one-quarter of the quantity of steam would have escaped, and it is quite possible that if the orifice had been ½ in. diameter no such trouble as afterwards occurred would have taken place."

The Commissioners further stated that "if, therefore, this formal investigation results in bringing home to users of boilers, to which fusible plugs are attached, the importance of procuring that the area is reduced to the smallest practical limits, some good will have been done."

The fact that the volume of steam and water which will escape through a circular orifice varies not as the diameter, but as the square of the diameter of the orifice, is apt to be overlooked, and the oversight may be attended with serious consequences, as we have seen. When a fusible plug is refilled with the fusible alloy, some slight enlargement of the orifice is generally necessary, and it will be obvious that, after the plug has been filled a number of times, the discharging capacity of the orifice may become increased to a somewhat serious extent. For this reason alone, it is always advisable to guard against having the opening too large in the first instance. Generally speaking, the diameter of the opening should not exceed ¾ in.

In conclusion, it must be admitted that there are many instances on record where fusibl plugs have failed at the critical moment, and for this reason they are looked upon with disfavour by many. It is, however, no exaggeration to say that, providing the design be satisfactory and the question of frequent cleaning and occasional renewal of the fusible alloy be given due attention, a fusible plug is almost as reliable in its action as any of the fittings attached to a steam boiler.

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Water-power in Ireland.—A recent issue of the *Times Engineering Supplement* contains an article on the possible power development of the Shannon for supplying Dublin and Limerick, and the Erne for supply to Belfast and Derry. The longest transmission would be about 120 miles, and each river is estimated to give 50,000 H.P. during eight months of the year, and from 20,000 to 40,000 H.P. during the remainder. The possibilities of Lough Neagh, which has an area about equal to that of the Isle of Man, are apparently discounted by the drop of only 40 feet over a distance of 60 miles to the sea; there is, however, an opportunity for some small local developments, such as for electric supply to the town of Coleraine. Proposals have been made to utilise the tides in Strangford Lough, which is convenient to Belfast, and is fed from the sea through a narrow channel, about four miles long and from a quarter to a half mile wide. The tides run about six hours each way, with two hours of slack water, when no head would be available. To overcome this it has been suggested to provide internal storage reservoirs by means of a barrage across the Quoile River estuary and a bay behind Mahee Island; also, as an alternative, to provide battery storage. Power would be generated by both the incoming and outflowing tides, and it is estimated that the power at the turbines would vary from 60,000 to 10,000 H.P., averaging with suitable storage 32,000 H.P. the year round. The capital expenditure on the scheme is estimated at £1,120,000, and the annual saving over a steam plant of similar capacity at about £120,000.

# Trade Items, Notes, &c.

Exorbitant Metal Prices in Sweden.—Owing to the scarcity of certain indispensable metals and the manner in which unscrupulous speculators have succeeded in securing what limited stocks there are in the country, some prices have risen to exorbitant levels. Tin now costs 23 to 24 kronor per kilogramme (about 14s. per pound), a rise of about 800 per cent. Antimony is held at 20 kronor per kilogramme (about 11s. per pound), a rise of 2,000 per cent, lead costs 2 kronor (about 1s. 2d. per pound), a rise of 600 per cent; and copper, which before the war cost 1 krona 75 öre per kilogramme (about 11d. per pound), now costs 6 kronor (about 3s. 6d. per pound).

Queensland Coalfields.—The Queensland Mines Department has received a report from its experts, who have been boring on the Bowen coalfields for some time, stating that they have now proved that within an area of one square mile there are 22,000,000 tons of coal. The electrolytic works at Bowen and the smelters and mines at Cloncurry would be very large consumers of coal were these fields exploited. Bowen and Townsville are the two nearest Australian ports to the Panama Canal, and this coal discovery must increase their importance, from the fact that ships leaving Australia for Panama would have to coal at one or the other of them. There are 500,000 acres of Crown lands on the Bowen coalfield district that can be made available for settlement at once.

The term "brazing brass" is usually applied to yellow brasses of composition ranging from 80 to 85 per cent copper and 20 to 15 per cent zinc, which will stand brazing with ordinary yellow brazing solder (50 copper, 50 zinc) without melting or cracking. These defects are liable with the brasses of low copper content, such as 60-40, on account of their low melting points. If tin is present in the brazing brass cracking is liable to occur, while lead also should be absent. The 80-copper, 20-zinc mixture is yellow in colour, but when the zinc is reduced to 15 per cent, with 85 per cent copper, the metal has an orange tint. The melting point of the lower zinc mixture is, of course, slightly the higher of the two, and hence it is the more suitable unless the colour is a matter of importance.

The formal announcement has now been made in Washington that the contract for the supply of 14-in. and 16-in. armour-piercing shells for the United States Navy has been awarded to Messrs. Hadfields Limited, of Sheffield. The total value of the contract is given as £628,200. Messrs. Hadfield's price for the larger sized projectile was as much as £40 below the lowest figure quoted by any American firm.

Transformers for Electric Railways.—On monophase railway systems a threefold current transformation takes place as a rule between the generating station and the engine motors. The last of these three transformations is effected on the engine, and there the volume and weight of the transformer are important factors. Yet the literature on electric railways says very little in general on the volume and weight of iron and copper, on the magnetising current, the iron and copper losses, and the ratio of maximum to permanent load, even in otherwise full descriptions of electric railways. This complaint is made by Dr. W. Kummer, of Zürich, in an article on "Alternating-current Transformers for Electric Traction," contributed to the *Schweizerische Bauzeitung* of March 10th. Dr. Kummer particularly wishes to know whether he is right in assuming, in his deductions, that the transformer constant is substantially the same for dry, air-cooled and for wet, oil-cooled transformers. His general expression for this constant is $V = C . (E . I)^{\frac{3}{4}}$, where V is the active transformer volume (the sum of the volumes of the iron and copper); E and I are the volts and amperes supplied, and C is the transformer constant. If the assumption be confirmed, then the preference for the more expensive oil insulation would be justified only by the greater safety of working, and Dr. Kummer makes an appeal for reliable data to settle this and other points.

The North German Lloyd. At the commencement of the war the company boasted a fleet, afloat or in course of building, of 102 ocean-going steamers, 40 coasting steamers, 68 river steamers, and 283 lighters. From the beginning of 1914 until the war broke out the company's steamers carried about 400,000 persons, and in the whole of 1913 an aggregate of between 600,000 and 700,000 passengers. The war has entirely upset its regular trade, but still the company has exerted itself in other ways. Since 1914 it has taken over 10 vessels in course of construction, with an aggregate tonnage of 70,000 tons gross, and there are still eight steamers being built, of an aggregate tonnage of 136,000 tons gross, including the Columbus and the Hindenburg, each of 35,000 tons gross. Of the company's 25,000 employees, some 6,000 men are serving at the front or in the navy.

Specimens of the important tungsten ores, wolframite and scheelite, have just been received at the Imperial Institute from the Federated Malay States, and can be seen in the Malay Court of the exhibition galleries. The most important use of tungsten ores is in the manufacture of tungsten steel, of which large quantities are now being employed in munition factories in the manufacture of high-speed tools and for other special purposes. Tungsten is also used in the form of wire in the manufacture of metallic filaments for electric lamps. Wolframite, commonly called wolfram, which forms the bulk of the tungsten ore produced, occurs in various parts of the main mountain range in British Malaya and in Pahang and Trengganu. Scheelite is mined at Perak and Selangor.

A committee of the new Institute of Victorian Industries, Australia, is ascertaining what can be done towards the profitable development of the Gippsland brown coal deposits. One of the most recent reports states that the brown coal beds of Victoria are the thickest yet recorded in the world. At Morwell 780 ft. of coal was passed through in a bore 1,010 ft. deep. The strata include one of 227 ft. 10 in., and another of no less than 265 ft. 6 in. The whole is of high commercial value, as shown by analyses made at period periods. The total quantity of brown coal in Victoria has been officially estimated at 30,000,000,000 tons. The greater part of it is found in four areas, of which the largest and apparently the cheapest to work is that in the Morwell district. This brown coal contains about 6,000 thermal units per pound.

Bauxite in Hungary.—A company, with a share capital of £333,000, has been formed at Budapest, under the title of the Aluminium Ore Mining and Industry Co., and under the presidency of the general director of the Hungarian General Credit Bank, to take over the bauxite mines of the Count Karl Kornis group in the districts of Bihar and Klausenburg. The object of the company, in which the German banking firm of S. Bleichroder, the Disconto Gesellschaft, and the metal firm of Aron Hirsch and Co. are also interested, is chiefly to work the mines in question, the large present output from which is mainly forwarded to Germany. The new company, however, proposes to establish plant for the treatment of the ores and the production of aluminium.

The I.E.E. Temporary Premises.—The premises of the Institution of Electrical Engineers having been taken over by the Government, the address of the Institution is, for the present, 1, Albemarle Street, London, W. 1. The telephone number is unaltered: "Gerrard 764." Telegraphic address: "Voltampere, Piccy, London." The meetings for the remainder of the session will, by kind permission, be held at the Institution of Civil Engineers, at 6 p.m. On April 26th, Mr. G. V. Twiss will read his paper on "High-Tension Overhead Transmission Lines," and on May 17th the annual general meeting will be held.

The Education of Marine Engineers.—The Council of the Institute of Marine Engineers has considered the subject above named, and has issued a report stating that the present system of education is capable of great improvement. Its recommendations include the teaching of physics, electricity, and chemistry in elementary schools, the provision of junior technical or trade schools for boys of 14 to 16, facilities for apprentices to attend classes, and the provision of scholarships to enable boys of exceptional ability to continue their studies. Modifications in the examinations of marine engineers for first and second-class certificates are also recommended, as well as the institution of a third class. An apprenticeship of at least five years is called for. No specific reference is made to training in electrical engineering, and in view of the growing importance of electrical applications on board ship, which are likely to attain the first rank in the near future, we think this is a regrettable omission.

# New Companies Registered.

BURCHETT AND GIVEN LTD. (146,772).—Private company. Registered March 22nd. Capital, £1,000, £1 shares. To take over the business of motor and general engineers carried on by E. Burchett and B. Given at 4-8, Wilton Crescent Mews, Belgrave Square, W. Directors: E. Burchett (managing director) and B. Given. Registered office: 4-8, Wilton Crescent Mews, W.

BURDETTE AND CO. LTD. (146,713).—Private company. Registered March 21st. Capital, £6,000, £1 shares (1,000 preferred). To take over the business of electrical and general engineers carried on by R. Speedy, G. L. Eynon, and J. Meech, at 7, Pocock Street, S.E., as "Burdette and Co." Directors; J. Meech, P. Speedy, and G. L. Eynon. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

COURSE AND SON LTD. (146,679).—Private company. Registered March 20th, by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C. Capital, £8,000, £1 shares. Millwrights, motor and general engineers, and agents carried on by W. and T. B. Course at Bedford, as "Wm. Course and Son." Directors: W. Course and T. R. Course. Solicitor: C. C. Bell, Bedford.

HIDER DEMPSTER AND CO. LTD. (146,627).—Private company. Registered March 19th. Capital, £1,000, £1 shares. Engineers, tool and boiler makers, electrical engineers, manufacturers of and dealers in armoury, etc. Directors: W. Hider Goodchild and R. Dempster Goodchild. Solicitor: H. W. Rydon, 77, Cornhill, E.C.

HUDSON'S ELECTRICAL ENGINEERING CO. LTD. (146,731).—Private company. Registered March 21st. Capital, £1,000, £1 shares. To take over the business of an electrical engineer, carried on at 3, Prudential Buildings, Park Row, Leeds, and elsewhere as "Hudson and Co." The subscribers are to appoint the first directors. Solicitor: A. Willey, Calverley Chambers, Victoria Square, Leeds.

ISENTHAL AND CO. LTD. (146,791).—Private company. Registered March 22nd. Capital, £5,000, £1 shares. To take over the business of an electrical engineer and manufacturer of and dealer in electrical and mechanical apparatus carried on by A. W. Isenthal at Denzil Works, Willesden, N.W., as "Isenthal and Co." Directors: A. W. Isenthal, 95, The Avenue, Ealing, W. (permanent), C. R. Isenthal, and L. F. Fogarty. Registered by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C.

UNIVERSAL MACHINERY CO. (LEEDS) LTD. (146,819). —Private company. Registered March 22nd. Capital, £1,000, £1 shares. Mechanical, motor, electrical, and general engineers, etc. Directors: G. Wickman and J. Barlow. Registered office: 62, Hunslet New Road, Leeds.

A. J. LYTHEER LTD. (146,828).—Private company. Registered March 23rd Capital, £1,000, £1 shares. To take over the business of manufacturers of high-grade piston rings carried on by A. J. Lytheer at 16-17, Loveday Street, Birmingham. Directors: A. J. Lytheer, Mrs. G. A. Lytheer, and W. A. Lytheer. Registered office: 16-17, Loveday Street, Birmingham.

COWAN ASHTON LTD. (146,925).—Private company. Registered March 28th. Capital, £2,000, £1 shares. To take over the business of engineers, engineers' merchants and agents, mill furnishers, and dealers in asbestos and rubber goods carried on by F. W. J. Ashton, as "Cowan and Co.," at 14, Market Place, Manchester. Directors: F. W. J. Ashton (chairman and governing director) and D. E. Ashton. Solicitor: J. Walker, 20, Kennedy Street, Manchester.

ECLIPSE CARBORUNDUM AND ELECTRITE CO. LTD. (146,853).—Private company. Registered March 24th. Capital, £10,000, £1 shares. To take over the business carried on at Apollo Works, South Road, New Southgate, N., as the "United Carborundum and Electrite Works Ltd.," and the "Vincit Co. Ltd." Agreements (*a*) with T. E. Fowler and (*b*) between the above companies, C. Eves and T. E. Fowler, for the purchase of assets by the said T. E. Fowler. Directors: J. F. Beale, S. R. Beale, and T. E. Fowler. Directors must be British, and the usual provisions for ensuring the general British nature of the company are inserted in the Memorandum of Association. Solicitors: Kenneth Brown and Co., Lennox House, Norfolk Street, W.C.

HOBRAN ENGINEERING CO. LTD. (146,906).—Private company. Registered March 27th. Capital £10,000, £1 shares. To take over the business of an engineer and manufacturer carried on by A. C. J. Wall at Wolverhampton, as the "Hobran Engineering Co." A. C. J. Wall is permanent director. Registered office: 313, Bilston Road, Wolverhampton.

MILLS AND KNIGHT LTD. (146,890).—Private company. Registered March 26th. Capital £50,000, £1 shares. Dry dock owners, repairers and builders of ships, vessels, and steam, internal-combustion and electrical engines, boiler makers, ship and boiler scalers, painters, etc., carried on by the executors of the late G. S. Knight at Nelson Road, Rotherhithe, and Fountain Dock, Bermondsey, S.E., as "Mills and Knight." Directors: A. G. S., F. W., and J. M. Knight. Solicitors: Carr,, Tyler, and Overy, 23, Rood Lane, E.C.

POWER ENGINEERING CO. LTD. (146,808).—Private company. Registered March 22nd. Capital 1,000, £1 shares. To take over the business carried on at Manchester by E. R. Voigt and partners, as the "Power Engineering Co." Directors: Emil R. Voigt (permanent director and secretary), Ernest M. Ginders, and Mrs. M. Voigt. Registered office: Thomas Street, Cheetham Hill, Manchester.

SOUTH WALES CHIMNEY AND FURNACE CONSTRUCTION LTD. (146,755).—Private company. Registered March 21st, by Jordan and Sons Ltd., 116-17, Chancery Lane, W.C. Capital £300, £1 shares. Directors: D. Evans-Jones, J. A. Davies, and J. Little (all permanent). Secretary: D. Evans-Jones, Rutland House, Swansea.

BRISTOWE MACHINERY DEPARTMENT LTD. (146,996). —Private company. Registered March 31st. Capital £2,000; 4,000 preference and 4,000 ordinary shares of 5s. each. To carry on the business of machinery manufacturers, etc. Registered office: 11, Tothill Street, S.W.

BROOKE ENGINEERING WORKS LTD. (147,056).—Private company. Registered April 5. Capital, £5,000, 4,500 preference shares of £1 each and 2,000 ordinary shares of 5s. each. To take over the business of engineers, metal workers, and aeroplane constructors carried on at Stoke Newington, N., as "Brooks Motor and Engineering Works." C. Sandys Balls signs as managing director. Registered office: Lawrence Buildings, Brooke Road, Stoke Newington, N.

GODWARD CARBURETTOR CO. LTD. (147,026).—Private company. Registered April 3rd. Capital 5,000, £1 shares. Carburettor manufacturer, etc. Agreement with Eclipse Petrol Economiser System Co. Ltd. Directors: E. B. Tredwen, A. Jackson, L. W. Barnes, and A. J. Jung. Gilbert McCaul and Co. are entitled to one nominee on the board, and may appoint a successor to E. B. Tredwen should he vacate office. Registered office: 53, Victoria Street, S.W.

RODGERS BROS. LTD. (147,037).—Private company. Registered April 3rd. 1A, Baker Street, Brixton, S.W. (9). Capital £10,000, £1 shares. To take over the business carried on at 1A, Baker Street, Brixton, S.W., as "Rodgers Bros.," Motor and general engineers, gear cutters, etc. Permanent governing director: H. C. Rodgers.

CLYDE FURNACE (CONTINENTAL) LTD. (9,825).—Private company. Registered in Edinburgh, March 30th. Capital £503, £1 shares. To take over certain secret processes and patent rights in France, Belgium, etc., and Colonies, relating to open-hearth furnaces, etc. Patents in name of Thomas B. Rogerson. Registered office: 116, Hope Street, Glasgow.

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THE ARMING OF JAPANESE SHIPS.—We are glad to note, says *The London and China Telegraph*, that the directors of the Nippon Yusen Kaisha have overcome their scruples with regard to the arming of their steamers as a protection against German submarine attacks. There can be no question that they have taken the right course, and in view of all that has happened the only surprise was that they should ever have had any hesitation on the subject. The day is past for any punctilious feelings so far as Germany is concerned, such as were indicated by the directors when they first announced their intention to run their vessels without guns. Japanese steamers have been attacked and sunk without warning, but armed as they will be in future with two guns on each vessel, the sinking may not be all on one side. The weekly statistics issued by the Government show that a very large percentage of armed merchantmen attacked by enemy submarines make their escape. At any rate, they were in a far better position to resist the sea pirates than if they had no guns at all.

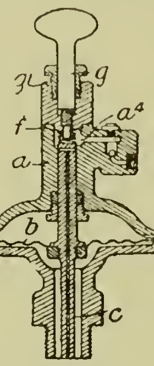
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

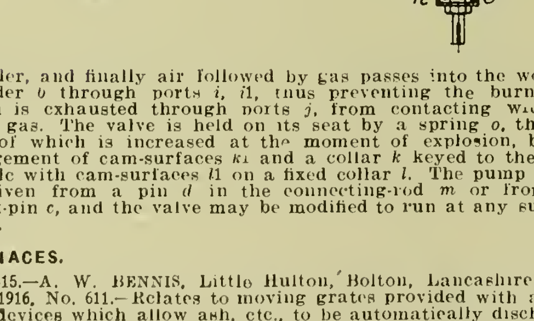
103,219.—C. E. LIEBENBERG, 4, Barnhurst Avenue, Northumberland Heath, Erith, Kent.—March 23rd, 1916. No 4,318.—A diaphragm pump *a* is mounted upon the engine cylinder and is actuated by




the explosion-pressure. Water is supplied to a chamber *a*4 and is forced through the hollow plunger *c* when the pressure beneath the diaphragm *b* is sufficient to raise it against the resistance of the spring *f*. The stroke is limited by an adjustable stop *g*. The plunger may be packed by a stuffing-box *g*1 or by a second diaphragm. The injection port may be overrun by the engine piston.

### INTERNAL-COMBUSTION ENGINES.

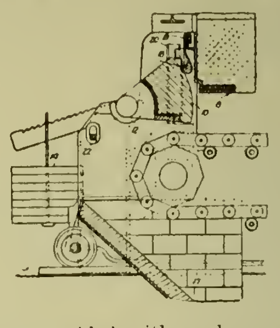
103,225.—H. B. BARWISE, High Croft, Duffield, Derbyshire.—April 8th, 1916, No. 5,182.—A rotary valve *f*, the interior of which communicates by a pipe *e* with the pump *a*, is provided with ports *p*, *p*1 and driven at half the engine speed so that gas and air are successively drawn through ports *g*, *h* and into the pump




cylinder, and finally air followed by gas passes into the working cylinder *b* through ports *i*, *i*1, thus preventing the burnt gas, which is exhausted through ports *j*, from contacting with the fresh gas. The valve is held on its seat by a spring *o*, the tension of which is increased at the moment of explosion, by the engagement of cam-surfaces *k*1 and a collar *k* keyed to the valve spindle with cam-surfaces *l*1 on a fixed collar *l*. The pump piston is driven from a pin *d* in the connecting-rod *m* or from the crank-pin *c*, and the valve may be modified to run at any suitable speed.

### FURNACES.

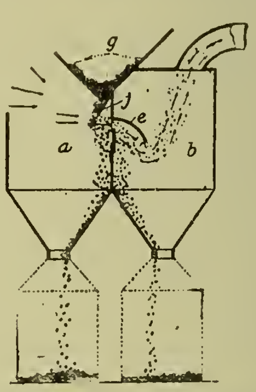
103,315.—A. W. BENNIS, Little Hulton, Bolton, Lancashire. Jan. 14th, 1916, No. 611.—Relates to moving grates provided with adjustable devices which allow ash, etc., to be automatically discharged without allowing entrance of air. In the construction shown, the travelling grate extends through an opening in the rear wall of the furnace, and the space above the grate is closed by an adjustable block 10 pivoted in bearings 12 and counterbalanced by adjustable weights 14. The space between the block and the furnace wall is sealed by a swinging plate 18 supported in a sand lute 19 and bearing against the curved face of the block. Hinged side seals 20 prevent leakage of air round the sides of the block, and a cross-bar 22 is provided for supporting a slicer when it is desired to remove clinker adhering to the grate. The ash, etc., falls into a hopper 17, or may be collected in tubs, or may be conveyed away by any suitable form of mechanical or pneumatic conveyor. The opening in the furnace wall may be arched, or the wall may be built on an angle plate 8. When forced draught is used, the rear end of the grate is enclosed within a casing. A sight-hole may be provided in the side wall of the furnace near the rear end of the grate, and the operating-lever for the block may be extended in proximity thereto. When a vertically sliding block is employed, an air seal is provided by a casing in which the block moves. The operating-chain passes through a



hole in the casing provided with a sleeve or gland. The invention is also shown applied to a water-tube boiler in which the bridge wall is spaced from the end wall of the furnace, and the gap between the two is roofed over to form a chamber into which the ash is discharged.

### SEPARATING OR GRADING COAL, ETC.

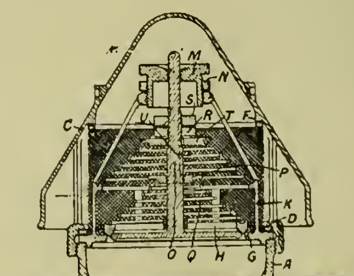
103,230.—W. YATES, H. W. S. MARTIN, and MATTHEWS and YATES, Cyclone Works, Swinton, near Manchester.—April 18th, 1916. No. 5,669.—Apparatus for grading coal, etc., comprises two chambers




*a*, *b* separated by a wall having an adjustable aperture through which a current of air flows. The material is fed from a hopper *g* provided with a hinged delivery plate *j*, which may be adjusted to regulate the distance of the falling material from the aperture. A deflector *e* is provided on the delivery side of the aperture, and the chamber *b* is connected to a fan and a cyclone separator.

### SAFETY-VALVES.

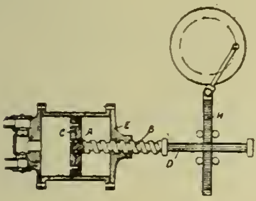
103,244.—T. A. CROMPTON, 29, Clarendon Gardens, Ilford, Essex.—May 22nd, 1916, No. 7,267.—A combined pressure and vacuum relief valve of the type in which the vacuum-relief valve member seats on the pressure-relief valve member has the adjusting-means for the loading-springs easily accessible. The pressure-relief valve member H is loaded by a spring Q engaging a groove on the back



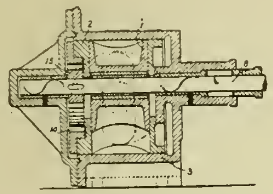

of the valve member and adjusted by a plate P coupled by arms O to a screwed member M provided with a lock-nut N. The member M screws in a cage K, which carries the main seating G and is either formed integral with the part A or detachably secured to it by a flange D on the cover C. The vacuum-relief valve is loaded by a spring U bearing against a ring on the cage and against a washer T adjusted by nuts R, S on the valve spindle. The outlet is protected by a gauze cylinder mounted on a skeleton frame clamped between the seat and a flange F on the cover C.

### RECIPROCATING PUMPS.

103,266.—F. ALLISON, Lilac Farm, Yeddingham, Heslerton, Yorkshire.—Aug. 15th, 1916, No. 11,526.—A pump for liquids or gases is actuated by a screw B on the pump rod A working in a threaded hole in the end E of the cylinder and oscillated by means of teeth D on the rod engaged by a reciprocating rack, etc., H. In the case of a double-cylinder pump with co-axial cylinders, the rod may have a screw on each end, with the teeth D between, or on one end only. The rod A is preferably revolubly connected to the piston C.



Patent 103,266.



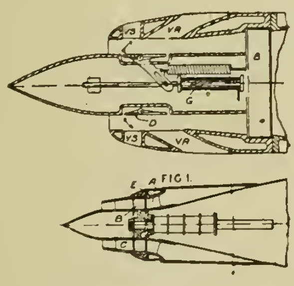
Patent 103,275.

### REVOLVING CYLINDER PUMPS.

103,275.—E. L. COPSEY, Old Heath, and F. W. BRACKETT & CO., Hythe Bridge Ironworks, both in Colchester.—Sept. 5th, 1916, No. 12,554.—In a valveless rotary pump of the kind in which the piston 1 rotates round an eccentric pin 8 supported at both ends in the casing 3, and reciprocates in a cylindrical bore in the driven cylinder 2 at right angles to the axis of rotation; as described in the parent Specification, the pin 8 is used as the driving-shaft and, in one form, carries a pinion 15 meshing with internal teeth 14 on the cylinder 2. A second set of teeth 14 may be provided on the other end of the cylinder to mesh with a second pinion on the shaft.

### PROPELLING SHIPS.

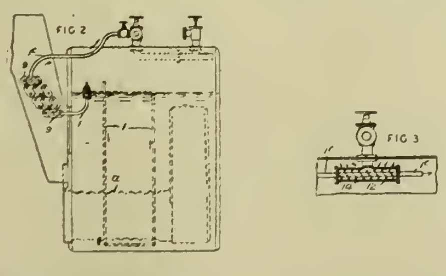
103,325.—R. O. KING, 10, Walmer Road, Toronto, Ontario, Canada. —Jan. 19th, 1916, No. 884.—The stern of a submarine or other vessel is provided with a jet-producing impeller or turbine B, Fig. 1, surrounded by a casing E having inlet and outlet guide-vanes A, C, the latter being so shaped that the rearward path of the water from the turbine through the vanes remains parallel



to the direction of motion of the vessel. This results in the efficient conversion of the pressure energy at the turbine into velocity energy at the discharge opening. In the form shown in Fig. 2, the jet passage is in the form of a hollow square and is fitted with pivoted deflectors D, operable by hydraulic or other means G, to discharge the water through steering-vanes V S or reversing-vanes V R.

### STEAM GENERATORS AND SUPERHEATERS.

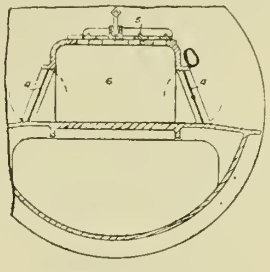
103,327.—F. NIBLOCK, 24, Queen's Road, Crosby, Liverpool.—Jan. 21st, 1916, No. 986.—To increase the water circulation in a boiler, and to superheat the steam, a pipe in the boiler conveys steam directly from the steam space through the lower water space and then conducts it to a superheater in the smoke-box or uptake. The superheated steam may be returned to the boiler steam



space. The steam pipe 1, Fig. 2, is carried down beneath the flue $a$, and is then passed through the boiler shell to the inlet of a U-tube superheater 9. The dry-steam pipe 1c may be taken through the internal steam-pipe 12, Fig. 3. Helical ribs 14 may be formed on the dry-steam pipe to compel the boiler steam to take a longer course through the internal steam pipe.

### FURNACES.

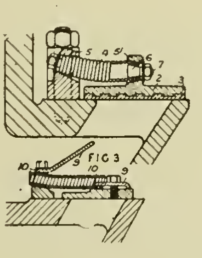
103,339.—J. HOWDEN & CO. and J. H. HUME, 195, Scotland Street, Glasgow.—Jan. 25th, 1916, No. 1,167.—An integral casting constituting the front of a forced-draught furnace is formed at the top and also at the sides of the firing-entrance with valve-controlled air ports, the arrangement being such that the valves 4, 5 control



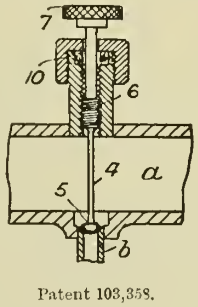
the flow of air direct into the preliminary mixing-chamber or firing-entrance 6, there being no air passages between the valves and the mixing-chamber. The arrangement is suitable for furnaces adapted for burning either coal or oil, or both combined, suitable burners being carried by the door.

### VALVES.

103,357.—H. A. HUMPHREY, 38, Victoria Street, Westminster, and W. J. RUSDELL, 45, Waterloo Road, Wolverhampton, Staffordshire. —Jan. 31st, 1916, No. 1,465.—A flexible check valve has the valve member supported and loaded by a series of coiled springs so arranged that the valve member is pressed to its seat by the flexure of the springs in a direction substantially normal to their axes. In the form shown in Fig. 1, the valve member 2 is provided with an india-rubber face 3, and the supporting-springs 4 have conical ends secured by coned members 6 and nuts 7 in recesses formed in lugs 5, 51 formed on the seat and valve member. The member 5 may be made adjustable so that the load on the valve may be varied. The spring may be rectangular in cross-section. An alternative method of securing the spring is shown in Fig. 3, in which the spring is secured by points 10 on pieces 9 engaging between the coils of the spring. In a further modification, the coils fit into cylindrical recesses and are secured by set-screws passed through loops formed on the spring. A series of these valves may have a common device for adjusting the springs, and a series may be mounted on a seat member removably secured in a casing by set-screws.



Patent 103,357.



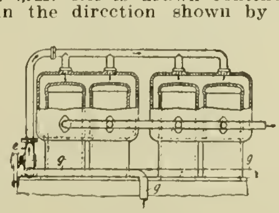
Patent 103,358.

### INTERNAL-COMBUSTION ENGINES.

103,358.—M. BRECHIN, Stuart Avenue, Scotstoun, Glasgow.—Feb. 1st, 1916, No. 1,505.—A pilot tube $b$ conveys mixture from a pilot-jet chamber to the induction pipe $a$ on the engine side of the throttle valve. The flow through the tube $b$ is controlled by a valve comprising a globular head 5 on a stem 4, which passes through the induction pipe without appreciably obstructing it. The valve stem is screwed at 6, passes through a stuffing-box 10, and is actuated by the disc 7. To permit of a small flow when the valve is in its closed position, slots may be formed in the globular head 5.

### INTERNAL-COMBUSTION ENGINES.

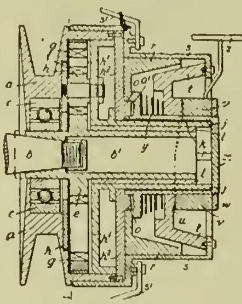
103,394.—J. E. BIRTILL, 5, The Mount, Altrincham, Cheshire.—April 4th, 1916, No. 4,921.—Air is drawn continuously through the cylinder jackets in the direction shown by the arrows, by a



rotary pump $e$ driven from the engine shaft at high speed. The hot air delivered by the pump may be conveyed through the pipe $g$ to the supplementary air inlet of the carburretter, or, in the case of a motor road vehicle, to a foot warmer.

### VARIABLE-SPEED GEARING.

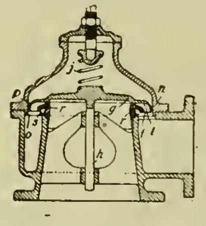
103,359.—C. M. COUCHMAN, Frogmoor House, Rickmansworth, Hertfordshire.—Feb. 1st, 1916, No. 1,516.—In two-speed epicyclic gearing for use with motor-cycle pulleys, the gearing is carried in a cage arranged within the driven pulley and is operated by a claw clutch for high-speed solid drive and by a cone brake for second speed. The driven pulley *a*, which may be of the expansible type, is mounted by a ball bearing *c* on the driving-shaft *b* and also bears on the outside of a cage *h*1, *h* carrying inter-engaging planet-wheels *f* engaging a ring *g* on the pulley *a* and a sun-wheel *e* on an extension *b*1 secured on the shaft *b*. A plate



*h*2 screwed to the pulley *a* carries clutch teeth *o* for engagement with similar teeth *o*1 on a brake part *r* sliding in an external casing *s* fixed by stays *s*1 to the frame. Castellations *k* on a closed extension *x* of the part *r* engage similar castellations on an extension *j* on the cage *h*1, which rotates on a bush *l* on the extension *b*1. An inner cone part *t* is secured to the casing *s* and has cam-surfaces *u* engaged by similar surfaces on a sleeve *v* bearing against a plate *w* screwed on the extension *x*. The sleeve *v* is rotated by pedals *z* and brings the parts *r*, *t* into contact to station the cage *h*1 for low speed, the clutch *o*, *o*1 being engaged by the spring *y* for solid drive.

### SAFETY VALVES.

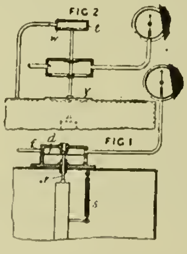
103,383.—K. ANDERSSON, 3, Buckingham Mount, Headingley, Leeds, and GREENWOOD & BATLEY, Great George Street, Westminster.—March 18th, 1916, No. 4,053.—A safety-valve loaded by a spring or weighted lever has the valve member and seat provided with radial extensions so shaped as to form a passage of gradually increasing cross-sectional area such that the escaping fluid is reduced to atmospheric pressure before leaving the passage.



In the form shown in Fig. 2, the valve member *g* is adjustably loaded by a spring *j* and is guided by a tail-piece *h*. The extension *l* on the valve member is provided with a turned-over lip *n* to increase the power of the escaping fluid to lift the valve; this lip may also be surrounded by a cylindrical casing *o* so as to form a narrow passage *p*, through which the escaping fluid acts to cause a reduction of pressure above the valve member. The extension *f* on the seat is formed with a groove *r* communicating with the outlet or the atmosphere through ports *s*. This feature may be dispensed with.

### INDICATING LIQUID LEVELS.

103,390.—F. H. CLIFT, 95, Castlenau, Barnes, Surrey.—March 27th, 1916, No. 4,500.—The upward pressure of a float in the liquid controls the escape of air under pressure from a chamber in communication with a pressure gauge, which thus indicates the liquid level. The float spindle *r*, Fig. 1, is connected to a corru-




gated diaphragm *d* forming the bottom of a chamber, to which air under pressure is admitted through a pipe *f*. In a modification, the spindle is also connected to a diaphragm *v*, Fig. 2, closing the top of the liquid vessel, and to a diaphragm *w* forming a wall of a chamber *t* in communication with the upper part of the liquid vessel. The weight of the float may be balanced by a spring *s* Fig. 1.

# INDEX TO ADVERTISERS.



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— THE —

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## The Industrial Engineer.

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## CONTENTS.



# EDITORIAL.

## THE BOY IN INDUSTRY.

Of the many problems which concern everyone engaged in industrial work, in addition to those which have cropped up in more insistent form during the progress of the war, none is more important as regards the future than the adequate and proper training of the boy in industry. The problem of his training is a difficult one, but whenever it has been tackled in a spirit of sympathy with the boy and an understanding of his nature, together with the limitations imposed by his youthfulness, success has resulted. It may not always have been an unqualified success, but certainly success of a degree to lend encouragement to further efforts. Efforts of the kind referred to have largely been made by a few firms who have seen a little beyond the mere question of turning out their products. More will have to be done in the future if we are to maintain our place amongst the great industrial nations, for upon the efficient training of our youth depends the future of British industry.

A timely reminder of what ought to be done is to be found in a small brochure, entitled "The Boy in Industry," issued by the Ministry of Munitions. This little work ought to be read by all those who have the welfare of our boys at heart. In a foreword, Dr. Addison, M.P., states that the number of boys between the ages of 14 and 18 engaged in various occupations in this country is approximately 1,250,000, and that "their young shoulders are gallantly helping to support the burden of war." But while the war has heightened the value of the boy in the labour market, it has intensified the problem of his welfare.

"The Boy in Industry" (H.M. Stationery Office, Kingsway, London, W.C.2; 3d. net) puts the case of the factory lad clearly and without concealment of unpleasing facts. The ordinary boy of 14 to 18 years, states the author, is "unstable, wilful, elusive; the age is a critical one in his career, and he is receptive to influences both good and bad—chiefly bad." To-day various contributory causes make his position more precarious; the father's control is absent, and high wages are paid for his labour. "The boy knows nothing of the part he is to play either in the world or in his work," and finding himself regarded as a man he thinks that the sooner he apes man's follies the better.

Various methods have been devised to stay this national waste, but the social and recreative agencies at work are insufficient. "A more highly-developed system of engagement and control" from inside the industrial system is essential. This could be accomplished, the author insists, by the appointment in the factories of a sympathetic supervisor who would watch the personal interests of the boys. This officer would engage all the lads, would keep in touch with them at work and at play and would encourage them in a wholesome outlook on life. Those concerned with the position of boys in industry would do well to read this "live" booklet from cover to cover, and to obtain the scheme for boy supervision in the munition factories from the Welfare Department, Ministry of Munitions, 6, Whitehall Gardens, London, S.W.1.

# THE APPLICATION OF COAL GAS TO INDUSTRY IN WAR TIME: ITS NATIONAL IMPORTANCE.*

By HORACE M. THORNTON, M.I.Mech.E.

WHEN I read my last paper before the Society, "The Uses of Coal Gas for Industrial Purposes"—now over two years ago—I then suggested that we were witnessing the dawn of a new era in industrial heating. On that occasion illustrations were given, by lantern-slides, of about 70 applications of coal gas to our largest national industries, representative of a very much greater number known to be in operation. In spite of these already numerous uses, industrial gas was then merely in its early development, and the realisation of the universality of its service was only growing gradually upon the manufacturers of this country. To-day he would be a bold man indeed who would define the limits of its penetration. The extent to which British industries, and therefore the nation at large, are under tribute to this great servant of the twentieth century is very much clearer now than it was even two brief years ago. It is probable that two years of war have taught us, as a nation, more than two decades of peace. Much that we have been forced to learn we would willingly forget; but if there are to be found any valuable products from this time of outpouring of life and treasure, one of the chief will surely be the great progressive movements which, under the stress of war-time conditions, have characterised our foremost industries. It has been so with industrial gas. Uses hitherto unknown have been discovered, uses hitherto regarded as impossible have been proved successful. Town gas, of which we thought we had known the full story for many years, and the decline in the use of which had often been prophesied—that common and ordinary lighting, cooking, and heating agent, delivered to us so simply through pipes into our homes—has proved to be much more potent and far more serviceable than our familiarity with it allowed us to conceive. To-day I wish to take up the story where I left it on the occasion of the last paper in March, 1915, and to give some account of the progress that has been made in the interval. At that time I gave, among details of many industries, particulars of a few of the uses of gas that were in operation for the production of armaments and munitions of war generally. To-day, so extensive are the uses of gas for these purposes, that they provide more than sufficient material for this paper—indeed, it is necessary, if your patience is not to be unduly tried, to restrict ourselves in the first place to a consideration of the uses of the gas furnace in the engineering world, omitting the wide application of this fuel to the glass, cotton, cloth, hat, boot, confectionery, food and many other trades, with which I dealt in my last paper, and which have during the last two years found still further scope for the utilisation of gas. I also desire to devote some time to the modern movement in regard to welfare work in factories and the part that gas plays in this important subject.

## Some Reasons for the Popularity of the Gas Furnace.

Before passing to the examples I wish to give and the illustrations I have to show, it will be of interest to trace some of the reasons which have led to the result I have described. Numerous and complex problems faced the engineers and manufacturers of this country anxious to respond to the call for "munitions, more munitions, and still more munitions." In many cases it was the problem of an immediate and enormous increase in normal production; in others, in many others, it was the problem of converting factories from the production of peace-time commodities to the turning out in vast quantities of war-time necessities.

Whatever the circumstances, the demand was for increased productivity, multiplied many fold on ordinary output, and this was required to be achieved with the utmost speed and in the face of an already heavy withdrawal of labour for military requirements. Under the stress of this need of maximum quantity with minimum labour at maximum speed many a manufacturer requiring a heat-treatment process—and heat is a well-nigh universal necessity in manufacture—sought and found the solution to his problem in the use of gas.

Let us look a little more closely into the facts as pre-

FIG. 1.—ANNEALING TOOL-STEEL BARS IN OVEN FURNACE, 22 ft. 6 in. long,

sented to industry when the demand for munitions of all kinds became insistent, and we shall see the part that gas for production purposes has played.

1. The volume of labour was reduced and, as events have proved, the manufacturer had to be prepared to face a still further decline. The gas furnace economised valuable labour, as no stoking was required; no fuel had to be transported or stored; no clinkering had to be done; no ashes had to be removed; very much less time was lost waiting for the furnace to heat up.

2. Existing factories had to be utilised to the full extent of their capabilities, for while we admire the gigantic enterprises of the Ministry of Munitions in erecting new factories, these took time to build, and a great accession to our materials of war was required immediately. Here the

* Paper read before the Society of Arts.

gas furnace, compact, self-contained and mobile, showed to advantage. It gave economy in space, and made possible an increase in output per unit of factory area. No smoke-stack was required; the choice for the position of the furnace was practically unlimited, enabling it to be brought into close proximity to the machine worker. No space was required for the storage of fuel or ashes. The capital expenditure in many cases was lower than for coal furnaces. No special structural alterations to the factories were required; no foundations were necessary; no provision had to be made for the extraction of smoke, soot or dust from the workshop.

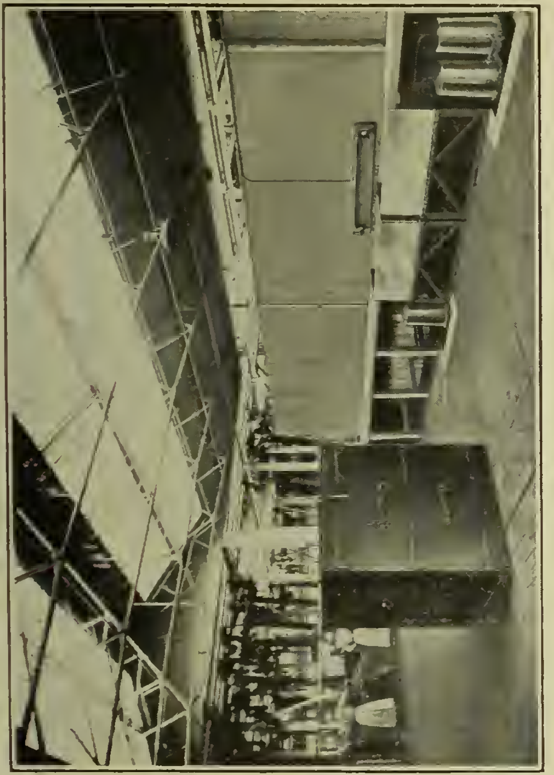

Fig. 3.—Shell Washing and Drying Plant.

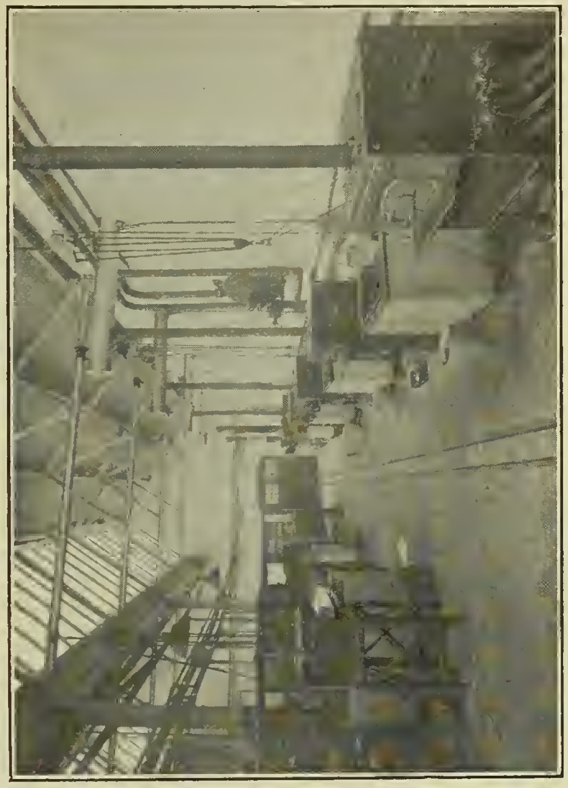

Fig. 6.—Suite of Tool-hardening Furnaces.

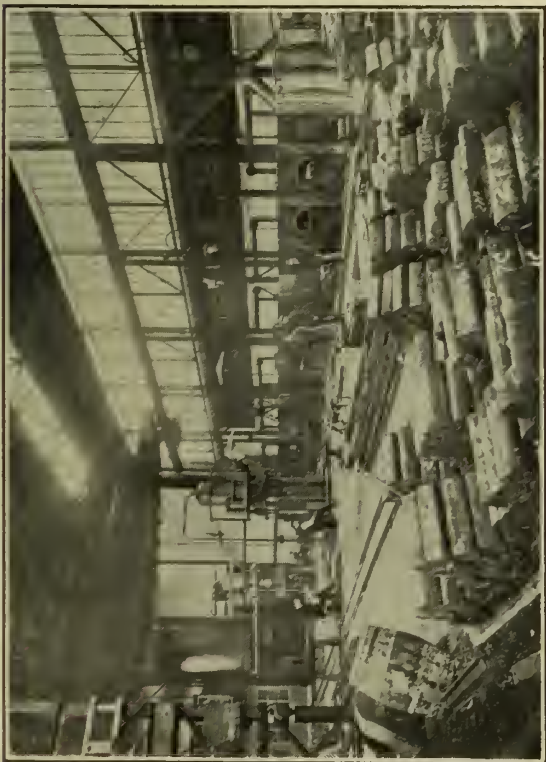

Fig. 2.—Billet Heating in Coke Furnace.

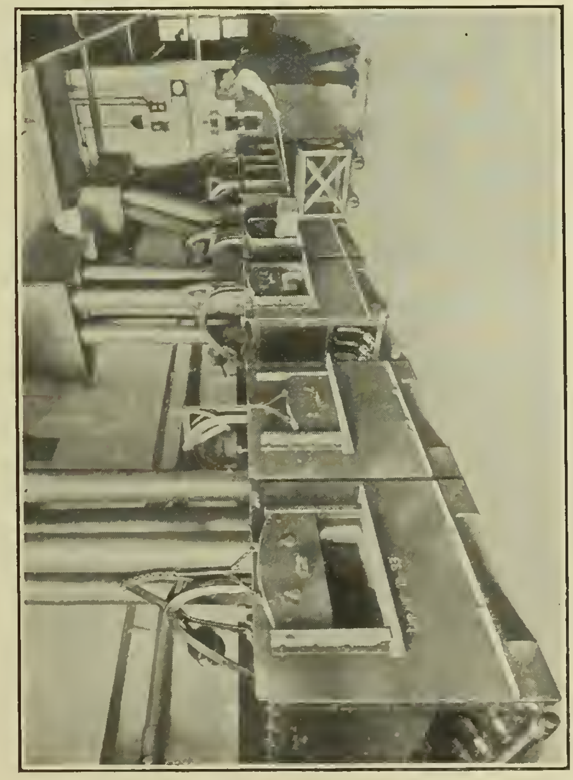

Fig. 4.—Case-hardening Component Parts of Rifles in Reverberatory Oven Furnace.

3. The most vital need was for an instantaneous, and yet abnormal, acceleration in production. The gas furnace, with its easy, accurate control of temperatures, and its constancy of action, "speeded up" the output, increasing the number of operations—annealing, hardening, melting, etc.—per working day by, in many cases, 100 per cent over crude heating methods. Its fuel was always available, and at a constant calorific value. With reasonable care there was no spoilt work and no "rejects" owing to irregular heating. The time required for each operation could be definitely ascertained, and the work could be performed at a uniform speed, enabling the works manager to depend on a constant supply of his heat-treated materials for the other departments of the factory.

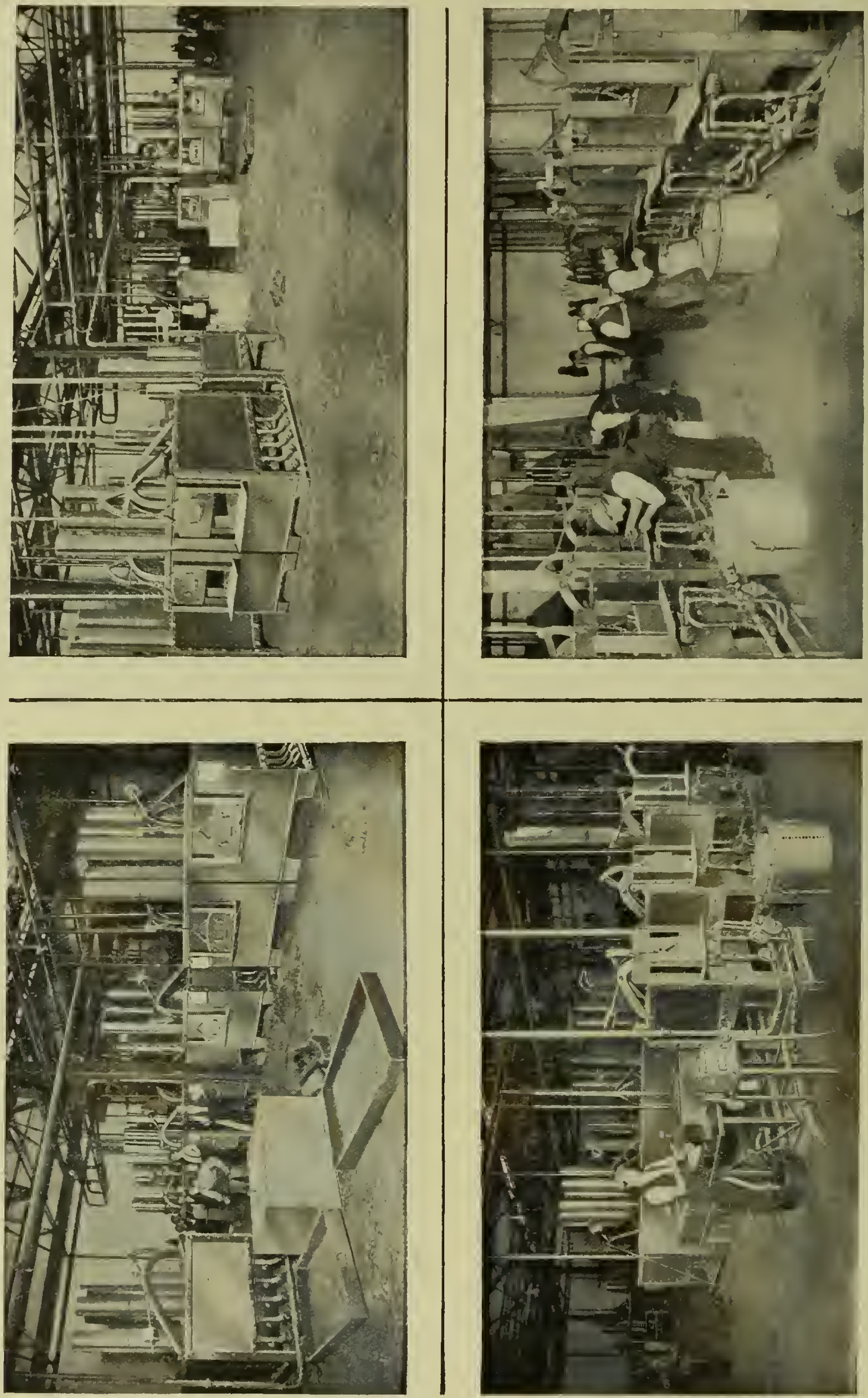

Fig. 5.—"Richmond" Patent Furnaces, installed in one of the Largest Hardening Shops in the Country.

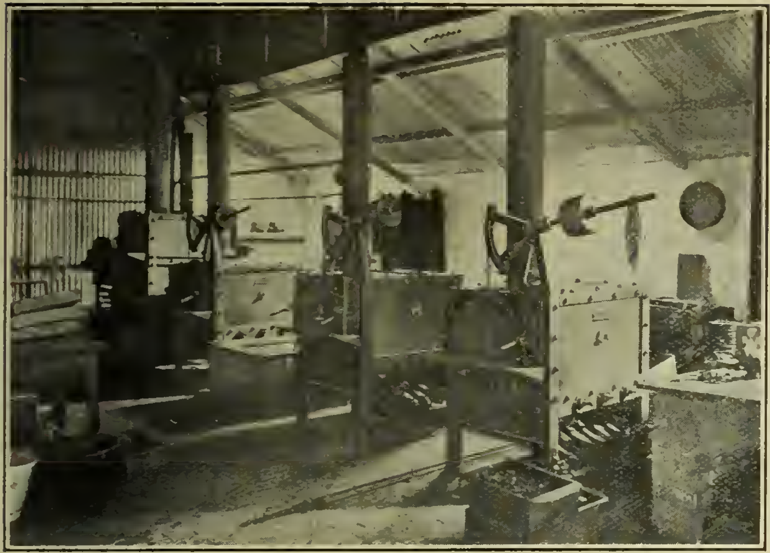

Fig. 7.—Re-heating Cycle and Motor-cycle Component Parts.

## The Uses of Gas Furnaces in the Production of Munitions.

We will now, with the aid of lantern-slides, examine a few of the actual uses to which gas furnaces have been put during these last two eventful years.

Dealing first, as is fitting, with steel, the slide shows a large natural-draught oven furnace, with inside length of 22 ft. 6 in. by 2 ft. by 1 ft., for annealing bars of tool-steel (Fig. 1). It takes a load of four tons per charge, and is one of the biggest coal-gas furnaces in operation in this country, consuming about 2,750 cubic feet per hour. The second slide also deals with annealing high-speed steel bars, but in a low-pressure-gas-and-air furnace, which is in Sheffield a very popular type for this purpose. This furnace takes charge of several tons, according to the section of the bars, and, at a temperature of 850 deg. Cen., it consumes approximately 3,500 cubic feet per ton annealed. Steel billets for many purposes are annealed or normalised in gas furnaces. I would, however, like to show you a suite of coke-heated regenerator furnaces for billet heating (Fig. 2). The mention of this fuel is not at all incompatible with our theme to-day, as it is the primary by-product of all gasworks. The slide shows a gas furnace for the "nosing" or "bottling" operation of shells. The next slide shows a gas furnace, also used in Sheffield, for the heat treatment of armour-piercing shells. After the shells have been machined, etc., they are carefully washed, and our slide shows gas-heated circulators providing the necessary hot water (Fig. 3). They are then varnished inside and stoved in the gas oven shown in the centre of the picture. Our next slide illustrates a much larger factory, and shows a battery of drying ovens in course of erection. The rails for the trolleys, to facilitate handling when loaded with heavy shells, will be noted.

From the shell we pass to the gun. Here gas finds its principal service in the manufacture and repair of howitzers and guns from the short 4·5 in. howitzer to the long naval gun, and the heights of the gas furnaces range from 8 ft. to 70 ft. In this case a photograph was impossible.

Next we turn to the rifle, and our slide shows furnaces for the hardening and care-hardening of rifle parts (Fig. 4). For this work gas furnaces are eminently suitable. Rifle breeches are also annealed in gas furnaces.

Our next four pictures are of the heat-treatment department of one of our largest works. All the furnaces you will see in the four slides are under one roof, and all use coal gas supplied from the gasworks. The first of the four shows natural-draught open furnaces for the heating of machine-gun barrels; the next is for other component parts of similar arms; the next shows various furnaces for annealing and hardening; the next a fine row of gas and air-blast furnaces for similar work.

To assist you to an impression of the extent of this heat treatment shop, I have had prepared a slide combining the four photographs shown (Fig. 5). This is undoubtedly one of the finest equipments in the country, and the selection of gas furnaces is confirmation of the claims I have advanced earlier in this paper.

## The Manufacture of Tools.

The use of gas furnaces in the manufacture of tools of all kinds—cutters, reamers, lathes and planing tools, broaches, etc.—

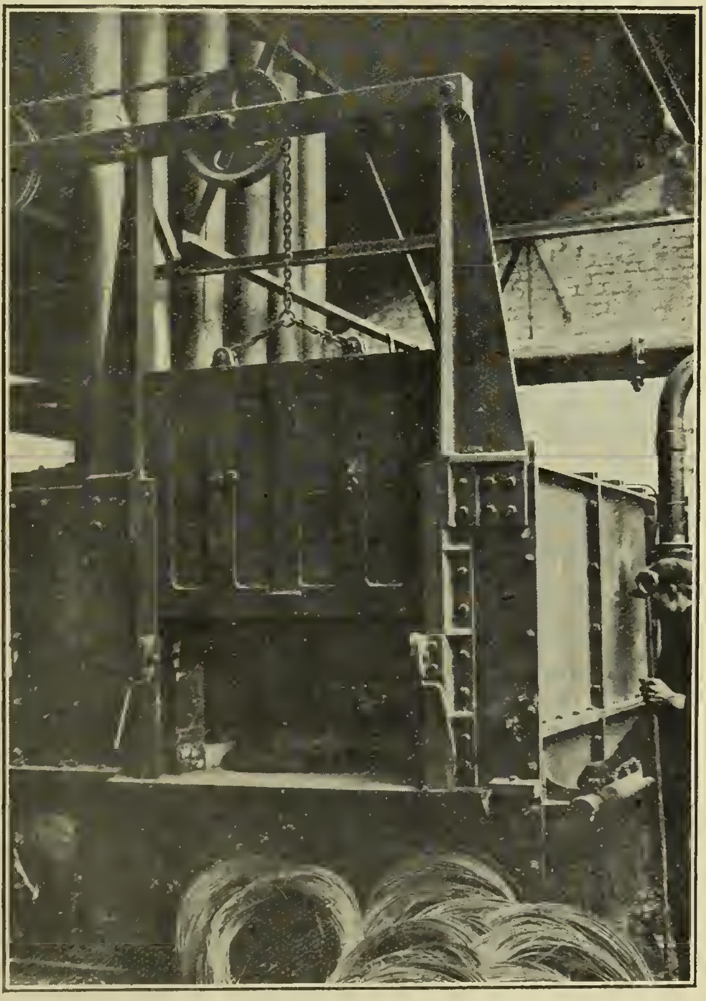

Fig. 8.—Annealing Wire in Gas-oven Furnace.

has expanded enormously since the war began. The careful heating of high-speed steel to critical temperatures, so necessary for good results, is accomplished perfectly with gas. Our next slide portrays harden-

ing furnaces in a large Midland factory (Fig. 6). The work of a shop of this kind is so complex, and so many different types of tools are produced, that it is impossible to go into details. Piercers or punches for shell bodies, spade-cutters for shell-boring, taps, dies, twist drills, broaches, and many other tools necessary for engineering work are all hardened in these furnaces. In the next illustration you see a man working at one of the popular twin-hardening furnaces. Air blast is used at about 1 lb. pressure per square inch. The tools are pre-heated in the upper chamber to about 900 deg. Cen., and then immediately transferred to the lower chamber at about 1,260 deg. Cen.

Nickel chrome and other alloy steels come into very wide use for war service. For all purposes where the highest possible tensile strength compatible with lightness is desired, these steels are in demand—for example, for the vital parts of motor-cars and aeroplanes, steeling levers, axle levers, stay-rods and landing-gear lugs, cam shafts, etc. A point of particular interest is the heat treatment of the special alloy steel used for the plates for the steel helmets of our soldiers. For this purpose the low-pressure gas and air furnace (as seen on the screen) has been found to be pre-eminently suitable on account of its equal heating and non-oxidising condition.

Coming now to the furnaces used for case-hardening, the next slide is of the hardening shop of a large cycle company (Fig. 7). The furnaces here are used in carburising component parts of bicycles and motor-cycles—cones, cups, speed-gear parts, pedal centres, spindles, etc.

The next slide takes us to the annealing of wire (Fig. 8), of which huge quantities are used by both Army and Navy for many purposes. The coils, weighing about 1 cwt. each, are taken to 800 deg. Cen. or thereabouts, and then are cooled off gradually in soaking pits. The gas consumption is about 2,000 cubic feet per ton.

*(To be continued.)*

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# BEARING LUBRICATION.*

By BOYNTON M. GREEN.

## Economic Value.

Assuming that a machine will do the work for which it is designed, its economic value depends on the degree of efficiency with which it will do that work. The energy supplied to it is consumed in three ways: in overcoming the external load, or in doing the actual work required of the machine; in deforming the various parts of the machine, and in overcoming friction. The energy consumed in doing the actual work required is a legitimate expenditure for which there is value received. If the machine is properly designed, the energy lost in deforming its parts is returned somewhere during the work cycle, because the parts will never have been stressed beyond their elastic limit, and hence, on returning to their original shape, will liberate the energy spent in deforming them, while that spent in accelerating masses will be given back upon their return to their original velocities. This leaves the energy lost in friction, which is a direct waste. Some friction is inevitable, so the question is: how may this loss be reduced to a minimum?

It is interesting to note that this important problem of design was the last one to be attacked from a scientific standpoint. For years after the designer was able to calculate with a fair degree of accuracy the stresses in frames, shafts, levers, and gears, he was content to design his bearings by guess and precedent. This tendency to slight bearing design was fostered by low machine speeds and lack of efficiency data. But with the introduction of electricity as a motive power and the resulting high speeds and ever-increasing demand for greater efficiency, the necessity for better bearing design became urgent.

## Investigating Conditions.

The first important attempt to investigate the conditions obtaining in a bearing was made in 1883 by Beauchamp Tower, an Englishman, at the request of the Institution of Mechanical Engineers. He used a journal 4 in. in diameter by 6 in. long, the bearing only covering the upper half of the journal. He was able first to explain the difference between partial or greasy lubrication and complete or flooded lubrication. Tower's results were qualitative rather than quantitative, but they brought out the facts that

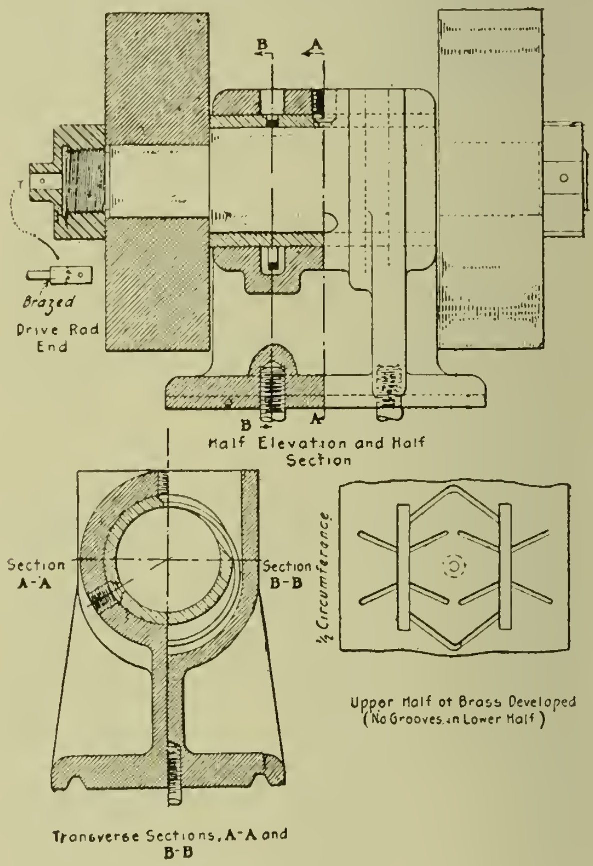



FIG. 1.—TEST BEARING.

there was probably a complete film of oil separating journal and bearing in the case of flooded lubrication, and that the conditions of bearing friction in the case of flooded lubrication approximate fluid friction more nearly than solid friction.

## The Basis of Mathematical Discussion.

The next step was made in 1885 by Professor Osborne Reynolds, who used Tower's numerical data as the basis of a mathematical discussion of the subject. Reynolds applied a hydro-dynamic theory to Tower's data and obtained an equation between the variation of pressure over the surface and journal velocity, which explained the existence of the oil film at a high pressure. He showed the presence of a wedging action of the lubricant, and this in turn brought out the importance of the bearing allowance, or difference in diameters of journal and bearing. From this followed

* From the Journal of the American Society of Mechanical Engineers.

the discovery of the general law for pressure distribution throughout the oil film, and the fact that the point of nearest approach of journal and bearing changes position with change of load. Reynolds realised that viscosity changes with temperature, so he made a determination of the relation between viscosity and temperature for olive oil, and deduced an empirical formula from which he obtained expressions for the approximate variation of viscosity with speed and load, since both these affect the bearing temperature. These expressions brought Tower's results into very close agreement with Reynolds' hydro-dynamic theory. The hydro-dynamic theory of fluid friction was also developed independently in 1884 by Petroff, a Russian.

### Flooded Lubrication.

This theory is undoubtedly the correct one to apply to the case of flooded lubrication. However, it cannot be applied directly, as the equations contain several constants which can only be determined by experiment, and it is to this work that later investigators have turned their attention rather than to the development of new theories. In 1903 some important investigations were carried on by O. Lasche for the Allgemeine Electricitäts-Gesellschaft of Berlin. Up to that time investigations had only been made with loads under 500 lbs. per square inch and velocities under 500 revolutions per minute (among the most important were those by Stribeck, Z.dV.d.I., 1902), and the A.E.G. found it necessary to obtain data for velocities up to 3,000 revolutions per minute and correspondingly high loads. Lasche's work was quite exhaustive and incidentally threw considerable light on the transmission of heat away from the oil film.

The general equation for fluid friction is

$$\mu = \eta V / py$$

where $\mu$ = coefficient of friction
$\eta$ = coefficient of viscocity
$V$ = journal surface speed
$p$ = pressure per unit of projected area of bearing
$y$ = mean film thickness.

Usually $p$ and $V$ can be determined from the conditions of the problem and values of $\eta$ can be taken from known data on oils. Concerning values of $y$, nothing definite is known, but some general deductions can be made. According to Smith and Marx's Machine Design, 1915, it is a function of the running-fit allowance, of $p$, of $V$, and of the temperature $t$ of the bearing, which may be summed up in the following expression

$$y = \frac{k_a V^x}{p^w t^2}$$

From a consideration of this expression and its application in the general equation for friction it would seem that the next step would be an investigation of the mean thickness of oil film. Some work was done on this subject in 1897 by Professor Kingsbury (Jour. Am. Soc. Nav. Eng.), but as he used air as a lubricant, his results can only be taken as an indication of what to expect when using oil. As the mean film thickness $y$ is influenced by four variables, it would be necessary to make the investigation in four steps. In Kingsbury's experiment the velocity only was changed. The pressure and allowance were kept constant, while the apparatus was allowed to run until the temperature became constant before any test readings were taken.

### The Influence of Velocity.

In the present experiment it was thought best to follow Kingsbury's lead and investigate the influence of velocity on mean film thickness, and the apparatus was designed with this point in view. The bearing is shown in section in Fig. 1; it is non-adjustable and consists of a plain phosphor-bronze sleeve about 3¼ in. in diameter by 7 in. long, pressed into a cast-iron housing which was bolted to a lathe bed. Lubrication was effected by two steel oil rings of rectangular section. Two sets of oil grooves were cut in the upper half of the bronze, as shown in the figure. On assembling the bronze sleeve and housing it was found that the bronze was elliptical in section, with the major axis vertical, the average difference in diameters being 0·001 in. To obtain the best results from the apparatus, the sleeve should have been reamed after pressing it into the housing. Although this was not done, the inaccuracy did not seem to affect the results appreciably.

*(To be continued.)*

## SELF-STARTING AND SELF-STOPPING ELEVATORS.

[Messrs. Edward Bennis and Co. Ltd., Bolton and London.]

The shortage of labour which has been developing with increasing seriousness ever since the first day of the war has now reached such a state of acuteness that manufacturers are literally tumbling over each other in their endeavours to find ways and means of overcoming the labour difficulty. The tendency to find efficient substitutes for manual labour was, of course, in evidence long prior to the war, it being obvious to the more progressive manufacturers that it was an economic gain to do as much work as possible with the expenditure of as little energy as

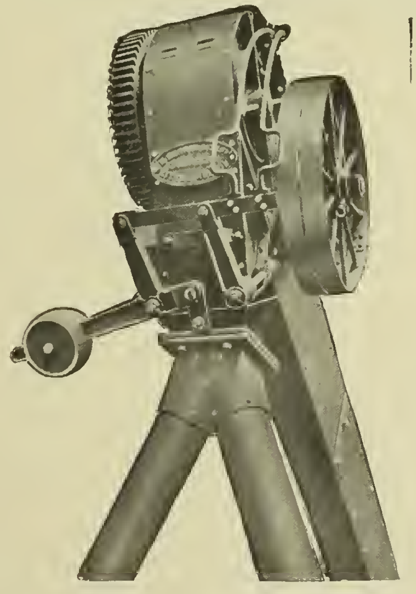


Fig. 1.—Elevator Running—Elevator Head.

possible. The war merely intensified this tendency through the rapid and unexampled depletion of the reservoir of labour, with, as a corrollary, the raising of its price to a point where it becomes the grossest inefficiency, as well as a criminal waste of national resources, to do by hand what can be done more cheaply and more efficiently by a machine.

Among many devices which have consequently come into favour, perhaps one of the most useful, as a factor in the efficient and economical working of boiler plant is that by which the elevators for feeding stoker hoppers with fuel are

rendered automatic in operation. This is fully attained in the automatic mechanism which has been added to the design of the "Bennis" Independent Elevators.

The "Bennis" Bucket Elevator consists of a strong steel chain to which buckets are attached at regular intervals, being kept in position by upper and lower guides. The buckets are formed of mild steel pressed out in one piece. The coal is fed into the elevator boot by means of the "Bennis" rotary safety feeder at a speed suitable for the buckets to take it up. This renders choking of the bucket by over supply impossible, while it obviates any wrench on the chain.

The automatic appliance which enhances the value and adds to the convenience of the elevator is quite simple. The shoots which feed the fuel from the elevator head to the hopper on store are swung on a balanced lever supported by the elevator head; the tail end of the shoot is supported by means of a chain, rod, or wire rope, as may be most convenient. The elevator feeds the coal into a small hopper forming the upper end of the shoot. When the shoot is empty, the weight on the balance lever draws the belt on to the driving pulley through a parallel link motion, so that the elevator is running. When the shoot fills, it overbalances the balance lever and pushes the strap fork on to the loose pulley, and the elevator is brought to a stop.

Fig. 2.—Elevator—Self Starter.

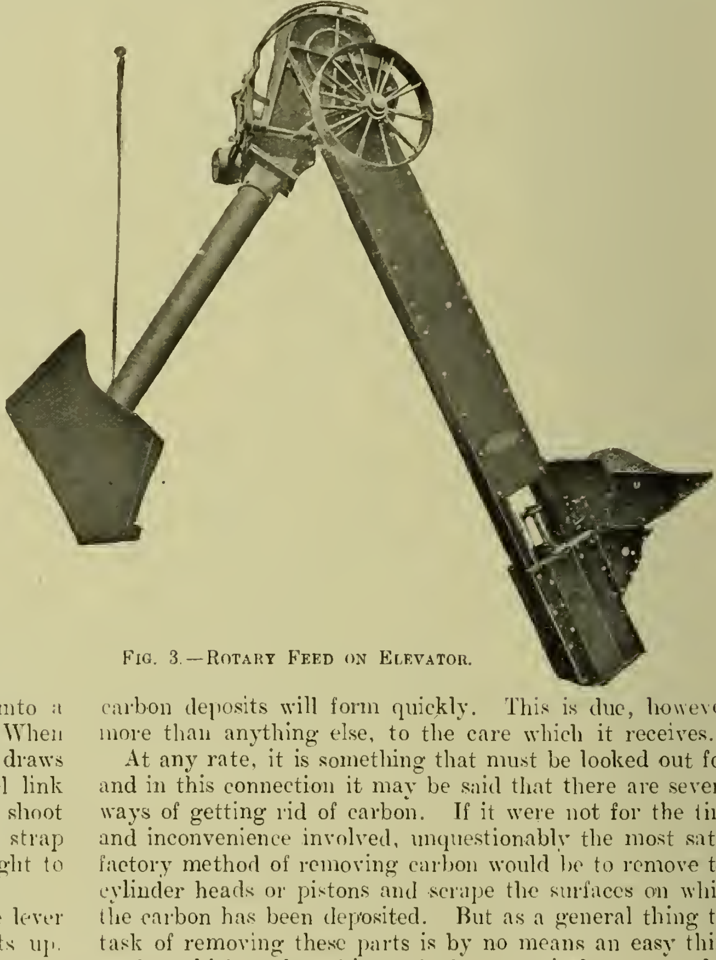


Fig. 3.—Rotary Feed on Elevator.

When the shoots are about half empty the balance lever comes into operation again, and the elevator starts up. By this means there is always a sufficient supply of coal to keep the hoppers full, but the elevator is never allowed to overflow. The rate of revolution of the rotary feed can be altered by the raising or lowering of a handle. The device, details of which are shown in the accompanying illustrations, can be applied to any existing elevator, whilst among other advantages, we may mention that the elevator cannot overfeed the stoker hoppers, and dribbling of fuel down the back of the elevator through over-feeding is eliminated; return shoots to the coal are rendered unnecessary; when the hoppers are full the elevator stops running, thereby greatly reducing wear and tear; the automatic action of the elevator renders an attendant unnecessary; the operation is silent, smooth, and silky; simplicity in design and strength in construction; low first cost.

The apparatus is manufactured by Ed. Bennis and Co. Ltd., Little Hulton, Bolton, and 28, Victoria Street, S.W. (1).

## REMOVING CARBON FROM GAS-ENGINE CYLINDERS.

### Getting Rid of Carbon.

Since carbon deposits in the cylinders of a gas engine may appreciably decrease the engine's power-producing efficiency, it is to the interest of every engine owner, for whatever purpose the engine may be used, to see that some means is employed, whenever necessity demands, to get rid of the carbon. Some engines will run a long time with practically no trouble from carbon, while in others carbon deposits will form quickly. This is due, however, more than anything else, to the care which it receives.

At any rate, it is something that must be looked out for, and in this connection it may be said that there are several ways of getting rid of carbon. If it were not for the time and inconvenience involved, unquestionably the most satisfactory method of removing carbon would be to remove the cylinder heads or pistons and scrape the surfaces on which the carbon has been deposited. But as a general thing the task of removing these parts is by no means an easy thing to do, which makes this method unpractical, except when the engine is being overhauled.

### Another Method.

Another method is to fill the combustion space of the cylinders with kerosene or denatured alcohol, after the engine has been run and while it is still warm, and allow it to stand for 12 hours, or overnight. The amount of these liquids that should be used will depend upon the extent of the carbon deposits, as will also the length of time they should be allowed to stand in the cylinders. The advantage of this method lies in the fact that neither the kerosene nor alcohol will harm the surfaces with which they

come in contact. On the other hand, there is the disadvantage of the long time required, together with the uncertainty as to whether or not the liquids have removed all the carbon. If splash lubrication is employed, the crankcase oil should be changed after the cylinders are treated with kerosene or alcohol, as much of these liquids will work past the pistons and find its way into the crankcase, thus destroying the lubricating qualities of the oil.

### The Use of Oxygen.

The use of oxygen for removing carbon deposits has come into extensive use during the past few years. The apparatus required consists of a cast-iron cylinder filled with oxygen under pressure, a pressure gauge, a length of hose, and a section of annealed copper tubing 12 in. to 15 in. long. The carbon in the combustion chamber is first ignited, after which the copper tubing is inserted in the cylinder and the oxygen turned on. The presence of the pure oxygen causes the ignited carbon to burn very rapidly, and the carbon deposits to be removed. When the burning is complete, it is to be supposed that the combustion chamber is clean. This is not usually so, however, since it is probable that sand or dirt is present in the combustion chamber which has been sucked in through the carburetter. A swab of some kind, or compressed air, should be used to get rid of such deposits.

Due to flying sparks which result when the oxygen is used and the nearness of gasoline, grease, etc., it is always best to have a fire extinguisher at hand to prevent a serious blaze.

The oxygen process of removing carbon has the advantage of doing the work quickly and with comparatively little inconvenience, but it is also more or less dangerous, as pointed out in the preceding paragraph. If one has the carbon burned out of his engine at a public garage it will cost him no less than 2s. a cylinder, and this is only possible with his automobile, for he cannot conveniently take his tractor and stationary gas engines to the garage for this purpose. The cost of an oxygen outfit would be about £5, and a cylinder recharged with oxygen would cost close on 8s. Only a few farmers would feel that they could afford such an outfit.

### Commercial Carbon Removers.

Various brands of commercial carbon remover have appeared on the market from time to time, many of which have been absolute failures or positive fakes. It is well for the engine owner to bear in mind that, unless such remedies are backed by responsible concerns, it is best to leave them pretty much alone.

There is such a thing, however, as a successful carbon remover that will give very good satisfaction, removing the carbon deposits from the engine very effectively, and greatly improving the operation. One decided advantage which such a remedy possesses over the use of oxygen is the ease of applying it, and the absolute absence of any danger of fire or harm from its use.

The carbon remover is poured into each cylinder at night through the pet-cock or spark-plug openings, and allowed to remain overnight. It acts in such a way as to soften the carbon, causing it to be loosened from the surfaces of the combustion chamber and piston head. When the engine is started the following morning, the carbon is blown out through the exhaust passages.

It goes without saying that a comparatively cheap, effective remedy for carbon deposits will be fully appreciated by owners of farm gas engines for all uses. And any manufacturer who has a successful carbon remover will find a ready sale for it.—*Gas Power.*

## THE CHOICE OF CONVERTING PLANT.

By F. Ashton.

(*Concluded from page 267.*)

### Starting Rotary Converters.

Rotary converters can, of course, be started on the direct-current side like other converters, and after they are started they are synchronised on the alternating-current side. But in the absence of direct current at the time of starting other methods must be adopted. One method is to apply alternating current at reduced pressure to the slip rings, whilst the field switch is open, when the machine runs up to speed in a similar way to an induction motor. The field switch is afterwards closed, and finally full pressure is applied to the slip ring. When the field switch is closed, however, the direct current voltage may build up in the wrong direction, and a reversing field switch is requisite, so that the polarity of the machine rectified before the full pressure is applied to the slip rings. Nowadays rotary converters are more often started with induction motors and synchronised with the alternating-current supply. It is now customary to connect the stator windings of the induction motor in series with the transformers and the slip rings of the converter, and the current which flows into the converter in consequence has the effect of pulling the machine into synchronism automatically. With this arrangement rotary converters may be started with great ease, and in the opinion of the writer this is the best method of starting that has so far been invented.

### Motor Converters.

When rotary converters were first introduced, they were not at all satisfactory on 60-cycle circuits. They were very apt to flash over at the brushes when short circuits occurred on the line. They were also liable to "hunt." This led to the introduction of the motor converter, a machine resembling a motor generator, but having the rotor of the induction motor and the armature of the direct-current dynamo electrically connected. One effect of this is that the converter runs at half synchronous speed, with the result that these machines operate very satisfactorily on 60-cycle circuits. The efficiency of a motor converter is not quite so good as that of a rotary converter with transformers, but very nearly so. Motor converters are easily started on the alternating-current side; they can be started on the direct-current side like a direct-current motor, they are reversible and a sufficent amount of voltage regulation for most practical purposes can be obtained at the direct end by adjusting the field rheostat. As a motor converter runs at half synchronous speed, half the energy is transmitted through the machine mechanically and half electrically. In many cases the three-phase current can be supplied directly to the stator windings on the induction motor side. It is only when the supply pressure is too high to be safely applied to a stator winding that transformers are needed.

### Conclusions.

Reviewing the subject in a broad way, it may be said that whenever large quantities of current have to be converted the highest possible efficiency should be aimed at. For small currents the utmost efficiency is less important, and the use of small motor generators is often permissible. Large motor generators, however, especially induction motor generators, should only be used under exceptional circumstances. Large induction motor generators are

now seldom installed. But when it is desired to convert direct current into alternating current without running the converter in parallel with other machines, the synchronous motor generator offers advantage over the rotary converter, but the superior efficiency of the latter may represent a large sum of money in the course of a year. Generally speaking, whenever it is desired to convert, on a large scale, polyphase current, and particularly 25-cycle current, into direct current, the rotary converter is the best machine to use. When reversibility is required, however, it may be better under the conditions mentioned above to employ a motor converter or synchronous motor generator. Although with the aid of commutating poles and other improvements the operation of 60-cycle rotary converters has within the last few years been greatly improved, and a large number of these machines are now in use (especially in America), the motor converter is still considered by many British engineers to be the best machine for this periodicity. From the point of view of efficiency, it is distinctly better than a motor generator. At various times there has been much discussion with respect to the ease and rapidity with which different kinds of converters can be started, and the advocates of different machines have claimed the particular converter they are interested in to be the best in this respect. With modern arrangements, however, all kinds of converters are fairly easily started, and in the opinion of the writer this is a matter which is now scarcely worth arguing about. For the production of high-voltage continuous currents—3,000-volt continuous currents, for example—motor generators composed of one alternating-current motor, mechanically coupled to two continuous dynamos, connected in series, have been adopted. The highest voltage for which rotary converters have been built in this country is 1,500 volts, and they are 25-cycle machines. The improvement in the operation of 60-cycle rotary converters working at ordinary voltages is not only due to better design, but also to the fact that most large power stations are now equipped with steam turbines having an even turning moment. The cyclic irregularity of reciprocating engines is apt to cause rotary converters to "hunt," and it is owing in no small measure to the elimination of these prime movers that 60-cycle rotary converters now run satisfactorily.

*(Concluded.)*

## THE INSTITUTION OF AUTOMOBILE ENGINEERS.

The eighth meeting of the session of the Institution of Automobile Engineers will be held on Wednesday, May 9th, 1917, at the Royal Society of Arts, John Street, Adelphi, W.C., at 8 p.m., when Mr. A. W. Reeves will read a paper entitled "Works Organisation."

An invitation is extended to all those interested in the subject to be present at the meeting, and a card of invitation may be obtained by forwarding a stamped, addressed envelope to The Secretary, Institution of Automobile Engineers, 28, Victoria Street, London, S.W. (1).

The Panama Canal.—According to the *Panama Canal Record* the total number of ships which passed through the canal from its opening on August 15th, 1914, to January 1st, 1917, was 2,780. Their gross tonnage was 13,086,535 tons, and their net tonnage 9,209,503 tons. The total quantity of cargo carried through the canal was 11,652,405 tons.

## METAL MELTING AS PRACTISED AT THE ROYAL MINT.*

By W. J. Hocking.

A brief general account of the Melting Branch of the Royal Mint and its work might form a suitable preface to this paper.

In this branch bars of the various coinage alloys are cast, preparatory to rolling. The metals used are usually procured in the form of fine ingots, and are alloyed in the proportions shown in the following statement:

Standard gold: $91\frac{2}{3}$ per cent gold; $8\frac{1}{3}$ per cent copper.

Imperial silver: $92\frac{1}{2}$ per cent silver; $7\frac{1}{2}$ per cent copper.

Coinage bronze: 95 per cent copper; 4 per cent tin; 1 per cent zinc.

Cupro-nickel: 75 per cent copper; 25 per cent nickel.

In addition to the fine ingots and alloy the average charge, to the extent of about one-third of the total, consists of scrap metal from the various processes of manufacture, returned for melting.

The bars cast are about 2 feet long, but differ in width and thickness according to the denomination of coin desired. The width varies from 4 in. in the case of bars for bronze coins to $1\frac{1}{4}$ in. in the case of those for threepences, and the thickness from $\frac{3}{8}$ in. for cupro-nickel bars to $\frac{3}{8}$ in. for bars for bronze. The bars are rolled in another department to the thickness of the coin required.

The average weight of the various classes of coinage metals cast annually during the last five years was about 2,000 tons, or a mean rate of a little over 7 tons (7,000 kilos) for the working day.

In melting gold and silver for coinage work, great care must be taken to secure in result the correct proportions of metals in the alloys as they were legally prescribed. The limits of variation from exact fineness are narrow, and are specified in the Coinage Act of 1891 (54 and 55 Vict., c. 72) as two parts per thousand for gold and four parts per thousand for silver. The variations permitted in practice are much less than these, and the necessity that the bars cast should be uniform in composition tends to restrict the size of the charges. The volume of the charge is mainly determined by the convenience of stirring it when molten and before pouring. Gold and silver bars are isolated in their respective "pots" until they are reported by the assayer to be either suitable or unsuitable for coinage. The usual charge of standard gold is 2,800 oz., or 87 kilos, and of silver 6,000 oz., or 187 kilos.

Two sets of furnaces are erected in separate rooms, the set of smaller furnaces being reserved exclusively for melting gold. The set of larger furnaces is used for melting silver, bronze, and cupro-nickel, crucibles of the same size being used for all three metals. About 400 lbs., or 182 kilos, is the weight of the charge of each of the two baser metals.

### Reorganisation of Melting Plant.

Owing to a steady increase in the demands upon the Mint in recent years for coinage, it became necessary to extend the capacity of the Melting Branch as well as that of other operations of coinage. It was not possible to enlarge the rooms for melting without a complete reorganisation of the whole Branch. Accordingly, the site was cleared, and new buildings were erected during 1910 and 1911. The

* Paper read before the Institute of Metals, March 22nd, 1917.

furnaces were rebuilt and adapted for gas fuel in substitution for coke. First of all, however, a protracted series of experiments was made with various classes of fuels and burners, and the most satisfactory results as to speed of melting and economy of cost were obtained by the use of coal gas at low pressure. These experiments numbered over 250, and were made with 19 different burners for oil and for gas, most of the burners being tried under various conditions of air and fuel pressures.

Unexpected circumstances arising during the transition period necessitated the adoption of experimental furnaces on a magnified scale. On the assumption that gold coinage would be suspended for a considerable period, the gold-melting house was transferred to the builders early in March, 1910. Before the end of the month, owing to public demands, an immediate resumption of gold coinage became imperative. Acting upon results of experiments made with oil and gas in 1909, four (subsequently increased to five) gas-fired furnaces were erected in a disused smithy. This small workshop, only 860 square feet in area, was provided with the usual fittings required in connection with the casting of gold bars for coinage, and was occupied for that purpose from May, 1910, to March, 1912.

A view of this improvised melting house is given (Fig.

FIG. 1.—VIEW OF IMPROVISED GOLD MELTING HOUSE.

1), showing the four furnaces and the general arrangement of the room.

The coinage demands proved heavier than usual, and during this period 874¼ tons of standard gold of the value of £111,199,403 were melted, the average melt for a working day being 1·829 tons (1,858 kilos), or £232,634 in value. In spite of drawbacks due to successive modifications of the new burners and to inexperience with gas as a fuel, the rate of out-turn was much accelerated as compared with former rates obtained with coke fuel. Although the total amount required for coinage was considerably in excess of the usual demands, a high rate of output per furnace was maintained throughout the period, and it was found possible with fewer furnaces to supply the rolling-mills with sufficient bars. For the ten preceding calendar years, the average annual production from eight coke-fired furnaces was 191 tons, while in 1910-12, with four (five for part time) gas-fired furnaces the annual out-turn was 437 tons, the crucibles used being increased in size in the latter period. The bars produced showed a greater uniformity in composition, and a decrease in the rate of waste in melting. A special test occurred in October, 1911. Fig. 2 is a plan of this room and shows a general during a long run which extended continuously throughout 27¾ hours. The total amount of gold melted was 257,052 ounces, or 7·87 tons (7,996 kilos), which is upwards of a million sterling in value. There were 102 pourings, and the consumption of gas was 32,000 cubic feet.

## New Furnaces for Melting Silver and Bronze.

The larger of the two new rooms for melting operations was completed before the close of this probationary period in the smithy, and work was commenced therein in January 1911. Fig. 2 is a plan of this room and shows the general arrangement of the plant. The room measures 105 feet by 52½ feet. Sixteen furnaces are constructed in line towards the centre of the room, arranged in two batteries,

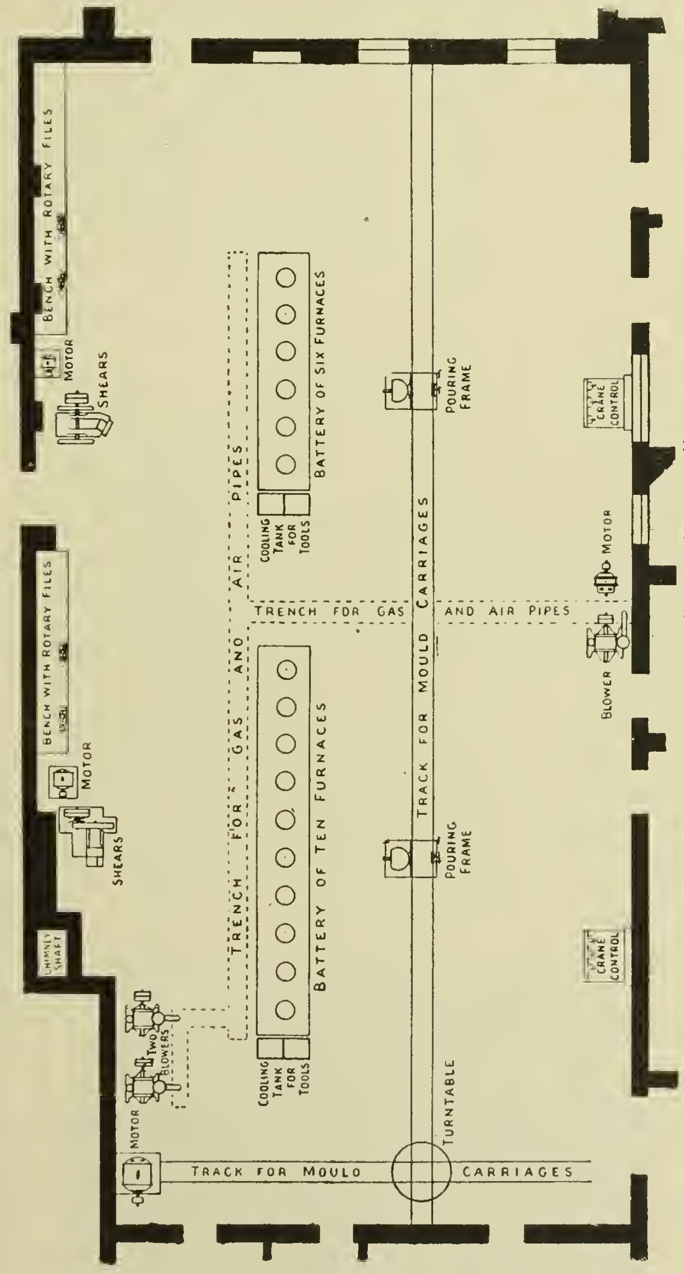



FIG. 2.—PLAN OF SILVER AND BRONZE MELTING HOUSE.

one of ten, measuring 34 ft. by 4 ft. 6 in., and one of six, measuring 21 ft. by 4 ft. 6 in.

The furnaces are built of Stourbridge firebrick, each well being 19 in. in diameter and 32 in. deep. The wells are lined with circular bricks, 3 in. thick, jointed with a refractory material composed of carborundum, firesand and silicate of soda, which is also used as a backing for the bricks. The face of the bricks forming the interior of the wells is treated with a wash made up of the same materials.

The whole mass of brickwork is braced together by a framework of iron bars to resist expansion, but is not enclosed with iron casing.

For convenience of charging the furnaces and of access to the crucibles for stirring the contents, the furnaces stand

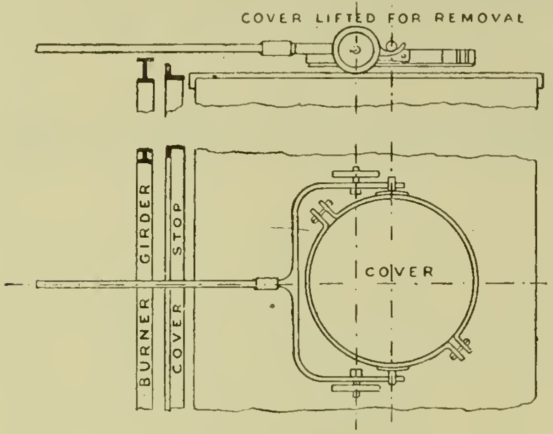



Fig. 3.—Cover Remover.

27 in. above the floor level. The tops are covered with cast-iron plates, 1 in. thick, bedded upon a ½ in. layer of asbestos cement. The plates are fitted loosely in sections to admit of expansion, and are shaped to allow a lip of brickwork around each furnace hole, 4½ in. broad. This ring of brickwork is made to rise slightly above the level of the iron tops, and serves to prevent the fusion of the iron coverings. The tops were at first carried to the edge of the furnace holes, and the molten iron scored the face of the furnace linings, necessitating frequent renewals

A circular firebrick, 27 in. in diameter, and 3 in. thick. is used to close the mouth of the furnace hole during melting. This cover is surrounded by two semi-circular iron bands, ¾ in thick, bolted together to form a frame. The cover, which weighs 1½ cwts., is lifted and wheeled into any desired position on the furnace top by means of a portable cover remover, designed in the Mint, and shown in plan and elevation in Fig. 3. The two ends of the lifter engage with a couple of lugs at opposite sides of the

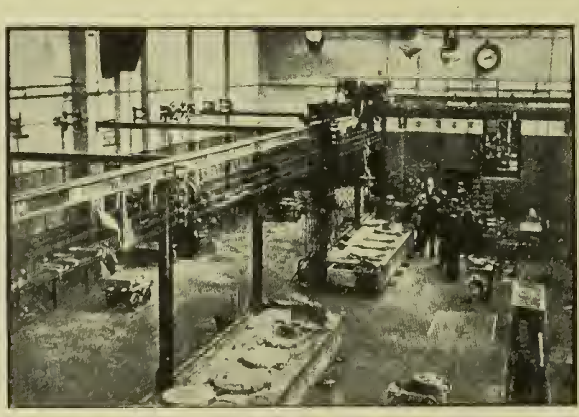


Fig. 4.—View of Silver and Bronze Melting House.

frame of the cover. A long detachable handle fitted with a socket serves to raise and guide the cover in the required direction, an operation easily performed from the back of the furnace. One of these tools is provided for each pair of furnaces

An electric-driven overhead travelling crane of 5 cwts. capacity hoists the crucible of molten metal from the furnace, and transports it to one of two pouring frames (Fig. 1). The movements of the crane are directed by means of switches situated at two platforms shown in the plan (Fig. 2). When in position for pouring, the crucible is gradually tilted by worm-gearing connected with the frame through the quadrant of a circle, and the contents poured into iron moulds. The moulds are set up in batches of about 40 in wheeled carriages which travel on a permanent track laid lengthwise of the room with a turntable and side track at one end (Fig. 2). During the process of pouring, the forward motion of the carriage on the rails as the moulds become full, as well as the upward movement of the crucible, is secured by rack and pinion gearing attached to the frame, the motions being actuated by separate wheels, controlled by two workmen. Fig. 4 is a photograph giving a general view of the centre of the room, showing the position of the furnaces, travelling train and pouring frame.

*(To be continued.)*

## BOILER FURNACE TEMPERATURES.

By George C. Cook.

In view of the modern developments in furnace design, a consideration of the temperatures created in the furnace is of interest both to the designer and to the operator. The attainment of high capacities and efficiencies is usually accompanied by high furnace temperatures, and a knowledge of their causes and effects is necessary for intelligent operation.

The term furnace temperature is rather vague, and it might be taken to mean the temperature of the fuel bed, the furnace walls, or the gases before striking the water-heating surface. However, the difference between these temperatures is relatively small, and, for all practical purposes, may be neglected.

The union of a combustible material with oxygen is what is known among chemists as an exothermic reaction; that means it is accompanied by an evolution of heat and an increase in temperature.

If carbon were burned in the theoretical amount of pure oxygen necessary for complete combustion, and all the heat developed in raising the temperature of the resulting gases utilised, a temperature of 18,000 deg. Fah. would be obtained. In burning coal, however, in a practical furnace, the temperatures are very much lower, owing to the following reasons:—

Instead of oxygen, air is used to support combustion, and almost invariably an excess of air over that theoretically required for complete combustion, give a much larger weight of gases to be heated. Some of the heat available in the coal is lost by incomplete combustion, by radiation to the surfaces exposed to the fuel bed, by dissociation of the resulting gases, by evaporating and superheating moisture in the coal and in the air supplied, and by heating the ash.

### Boiler Temperatures.

For these reasons, the temperature in the furnace of a steam boiler rarely, if ever, exceeds 3,000 deg. Fah. The temperature rise, then, is equal to the calorific value of the fuel minus the losses due to the foregoing causes divided by the product of the weight of gases times their specific heat. An increase in the furnace temperature may be made in the following ways: Using a coal with a higher calorific value,

decreasing the amount of excess air supplied, obtaining more complete combustion and decreasing the amount of heat radiated from the fuel on the grates. The furnace temperature may also be increased by pre-heating the air admitted for combustion.

In connection with boiler-furnace work it will be of interest to note the effect of increased furnace temperature on the heat absorption and efficiency, this effect depending on the means used in increasing the temperature.

If all other conditions are maintained constant, but a coal of a higher calorific value is substituted, the total heat absorbed will be higher and the efficiency will be higher, since there will be a greater amount of heat absorbed by direct radiation. If the amount of excess air supplied is decreased, or a more complete combustion is obtained, both the heat absorption and efficiency will be increased. If the amount of heat radiated from the furnace walls is decreased, both the heat absorption and the efficiency are increased, but cut down the amount of heat radiated to the water-heating surface, and it will be found that both the heat absorption and the efficiency are decreased. Preheating the air admitted for combustion will increase both the heat absorption and the efficiency.

### Temperatures and Superheaters.

In the case of boilers equipped with superheaters, changes in the furnace temperature will, of course, affect the degree of superheat obtained. If the superheater be of the type that receives the gases direct or after passing over only a small portion of the water-heating surface, the degree of superheat will increase with an increase in the furnace temperature, provided, of course, that the velocity of steam through the superheater remains constant. If the superheater be of the type that receives the gases from the boiler after they have passed over all the water-heating surface an increase in the furnace temperature will result in an increase in the degree of superheat, except when the heat in furnace temperature is due to a decrease in the amount of excess air supplied, in which case the degree of superheat will decrease.

### Temperature and Clinkers.

Increasing the furnace temperature is likely to give rise to difficulties from the formation of clinker. Coal ash becomes plastic, or even liquid, at certain temperatures, depending on its composition. When these temperatures are reached, the ash will fuse and tend to clog the grates, interfering with the air supply and decreasing the rate and efficiency of combustion. This tendency is increased if, in the manipulation of the fire, the ash is raised to the surface of the fuel bed and exposed to the full furnace temperature. If the fuel bed is not disturbed and the ash is allowed to remain below the surface, the ash will be cooled by the air admitted for combustion and may not form clinker, although the temperature of the furnace be greater than its temperature of fusion. This condition is difficult to obtain in practice, however, for when high rates of combustion are desired, considerable manipulation may be found necessary to obtain them.

High furnace temperatures are usually accompanied by increased depreciation of the brickwork and ironwork of the furnace. The fluxing action on the brick of small particles of ash carried by the combustion gases is accelerated by the higher temperatures, and sometimes temperatures are reached above the fusing point of the brick itself. Another cause of increased depreciation of brickwork with high furnace temperatures is the increase in the harmful effect of the sudden inrush of cold-air currents due to opening of firedoors, etc. The furnace ironwork also suffers increased depreciation with the higher furnace temperatures to a greater or less extent, according to the care taken in the design to utilise the protection afforded by the ash and the air supplied for combustion.

The temperature of combustion is largely determined by the design of the furnace. The most important features of the design in this respect are the arrangement of brickwork and heating surface, the volume and length of the combustion space, and the type of grate or stoker. These items affect the furnace temperature because they control the degree of the completeness of combustion, the amount of radiation, and to some extent the amount of air admitted.

### Arrangement of the Heating Surface.

With respect to the arrangement of heating surface, furnaces may be divided into two classes—those in which the fuel bed is directly exposed to the heating surface and those in which the brickwork is so placed as to prevent the fuel bed from "seeing" the heating surface, as, for instance, the dutch-oven type of setting. In comparing the two classes the first will give lower furnace temperatures, but at the same time a somewhat higher efficiency and capacity, with various rates of combustion up to the point at which unconsumed gases strike the heating surface, chilling them below the ignition temperature and resulting in heat loss due to incomplete combustion. This seeming paradox of higher capacity and efficiency with lower furnace temperature is explained by the fact that a large amount of heat is absorbed by direct radiation from the fuel bed to the heating surface, resulting in a lower furnace temperature, and consequently in a lower gas temperature at the entrance to the tubes. The lower the temperature of the gases entering the tubes the lower will be the exit temperature. A lower exit temperature for the flue gases means that a larger percentage of the heat liberated from the coal has been absorbed by the boiler, giving both higher capacity and efficiency.

The counterbalancing disadvantage of this class of setting is, however, that the volume of combustion space is usually less than for the other class exemplified by the dutch-oven type, consequently it is more "smoke sensitive," and its capacity for burning coal with reasonably complete combustion is less. Midway between these two types are the furnaces having their heating surfaces shielded from the fuel bed by arches or baffle tile. In this arrangement considerable heat is radiated to the heating surface from this portion of the brickwork.

### The Degree of Combustion.

The degree of completeness of combustion obtained is an important factor in the temperature developed. In order to have complete combustion, we must maintain the gases above the ignition point and have them thoroughly mixed so that combustion may be complete before they are cooled by the heating surface. The ability to establish this condition is largely dependent upon the design. Often in hand-fired furnaces various devices, such as arches, brick piers, wing walls, air and steam jets, are installed to accelerate the mixing of the gases. These are usually successful in improving the combustion, but their maintenance is high, and as they increase the loss in draught through the boiler, they decrease the capacity that can be obtained with a given draught.

What the volume of combustion space and the length of flame travel should be is an important question, and many installations of the past owe their lack of success to neglect to make ample provision in this respect. The necessary

amount of combustion space to ensure reasonably complete combustion is dependent upon the type of furnace, the rate of combustion, and the amount of volatile constituents in the coal. There is little exact information available on this subject, and the designer should be governed in his design by a consideration of successful installations having similar conditions to the one contemplated.

### The Materials Chosen.

It is of the utmost importance that the materials of which the furnace is constructed should be especially chosen to meet the proposed conditions with respect to character of load, furnace temperature, and character of coal, particularly with respect to the composition of its ash. For example, with reference to the selection of firebrick, where there is a steady load, and the ash of the coal burned does not exert an appreciable fluxing action on the brick, any good grade of firebrick whose fusing temperature is greater than the maximum furnace temperature obtained would be satisfactory, if properly installed and given reasonable care. Where the fine ash carried through the furnace by the gases exerts a fluxing action on the brick, the brick used in that part of the furnace exposed to this action should be especially chosen for its ability to resist this influence. In many cases the ash in the fuel bed itself exerts a very destructive effect on the brickwork exposed to its influence. Where the load is exceedingly variable, and where sudden inrushes of cold air into the furnace cannot be avoided, heavy stresses are set up in the brick, which call for a brick mechanically strong and with a minimum tendency to spall.

In the operation of the boiler plant it should be borne in mind that it is sometimes possible to obtain economy in the cost of fuel at the expense of excessive depreciation of the installation, and an endeavour should be made to strike such a balance between the two that the true cost will be a minimum. As an example, the writer has in mind a plant in which the operatives, in the desire to carry a high $CO_2$ percentage, developed a furnace temperature above the fusing point of the firebrick, and as a result the brickwork failed in a few weeks' time. By making a small sacrifice in efficiency, this condition was overcome and steam was generated at a lower cost and without trouble due to shutdowns.—*Power*.

## COAL GAS AS A FUEL FOR MELTING NON-FERROUS ALLOYS.*

By George Bernard Brook.

(Lecturer in Non-ferrous Metallurgy in the University of Sheffield.)

The use of gas for the melting of metals has always seemed to the author to be ideal. Some years ago he, in conjunction with Mr. C. O. Condrup, determined the relative costs and efficiencies of coal, oil, and gas, as fuels for the melting of brass, over a continuous run of fourteen hours. The experiments were carried out in furnaces side by side, in 30 lb. heats, the furnaces being run, without intermission, for a period of fourteen hours. Each furnace was worked by an expert on that particular type, and each furnace was selected as being the most reliable and efficient one of its type at the time the test was taken. A section of the coke-fired furnace is shown at Fig. 1. The summarised results of the test are shown in Table I., and the deductions drawn at the time from this test were as follows:—

(*a*) That although the oil and gas furnaces were obviously working at a disadvantage in using a crucible smaller than the size for which they were built, they secured a larger output than the coke-fired type.

(*b*) The greatest speed with which the first cast could be made, starting with the furnace cold, was found to be with the oil-fired furnace.

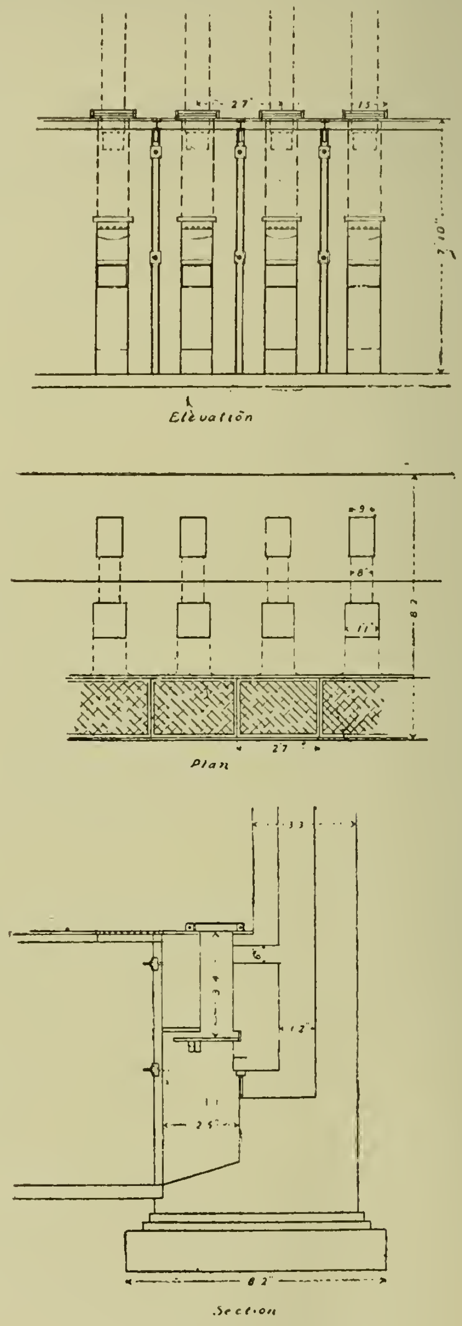



Fig. 1.—Coke-fired Pit Furnace.

(*c*) The minimum time taken for the melting of any of the charges was shown by the gas furnace, viz., nineteen minutes (times from charging to pouring).

(*d*) The total cost per 100 lb. of brass was distinctly in favour of the use of gas; the relations being—gas, 100; coke, 135; oil, 267.

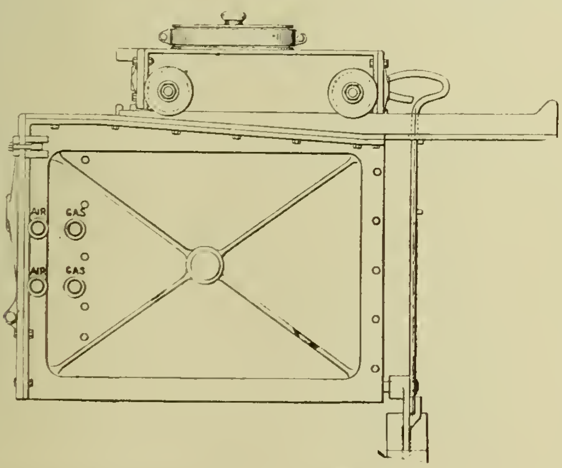
* Paper read before the Institute of Metals, March 22nd, 1917.

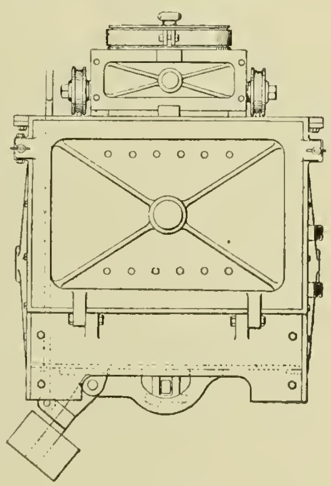
TABLE I.—Summary of Experimental Run of Fourteen Hours. March 10th, 1914.

| | | Coke. | Oil. | Gas. |
|---|---|---|---|---|
| 1 | Output on 14-hour run (total, 2,220 lbs. brass) | 720 lbs. | 750 lbs. (*a*) | 750 lbs. (*a*) |
| 2 | Weight of charge | 30 ,, | 30 ,, | 30 ,, |
| 3 | Number of casts | 24 | 25 (*a*) | 25 (*a*) |
| 4 | Time taken for melting initial 30 lbs. charge, starting cold furnace | 89 min. | 70 min. (*b*) | 78 min. |
| 5 | Time taken for melting subsequent charges, minimum | 22 ,, | 20 ,, | 19 ,, (*c*) |
| | Time taken for melting subsequent charges, maximum | 37 ,, | 41 ,, | 34 ,, |
| | Time taken for melting subsequent charges, average | 29 ,, | 29 ,, | 27 ,, |
| 6 | Fuel, cost of | 24s. per ton | 80s. per ton | 10d. per 1,000 cubic feet. |
| 7 | Fuel, heat value (British thermal units) | 12,960 per lb. | 19,700 per lb. | 570 per cubic foot. |
| 8 | Consumption of fuel per 100 lbs. brass melted | 66 lbs. | 4·1 gallons | 383 cubic feet. |
| 9 | Cost of fuel per 100 lbs. brass | 8·6d. | 15·3d. | 3·8d. (*d*). |
| 10 | Electrical energy for blast at 1d. per unit | Nil | 3·3d. | 1·1d. |
| 11 | Cost of graphite crucibles (on a basis of a 48 heat life) | 2·5d. | 3·3d. | 3·3d. |
| 12 | Total cost of melting 100 lbs. brass | 11·1d. | 21·9d. | 8·2d. (*d*). |
| 13 | Zinc loss on 100 lbs. brass | 0·40 per cent (*e*) | 0·85 per cent | 0·44 per cent. |
| 14 | Sulphur (absorbed from fuel) per cent per cast | 0·0040 | 0·0010 (*f*) | 0·0026 |

(*e*) The zinc loss, as might be expected, is lowest in the coke-fired furnace, as such loss is to some extent affected by the forced blast in the two other types of furnaces.

(*f*) The sulphur content is lowest in the oil-melted alloy, and highest in the brass produced in the coke-fired furnace.





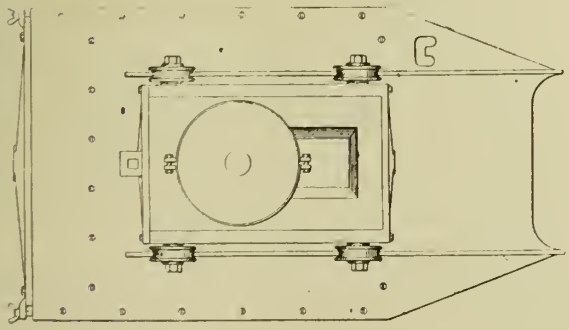



Fig. 1a.

It will be noticed that the cost of the gas in the above test was based on the current price as supplied to users of gas engines in Sheffield (see summary).

Whilst the author recognises the limitations of the above tests, he thought it might be useful to have them for comparison, since they prompted the more extensive test, which forms the basis of this paper.

In order to make the test as drastic as possible, cupro-nickel (80 : 20) was chosen as the test alloy in view of the high temperature required for this particular material.

In this further test every endeavour was made to ensure that the work should be on as large a scale as possible, closely following commercial practice, so that results obtained would be accepted by manufacturers as a guide to what might be expected in their own melting shops.

During the ten working days covering the period of the test, the total weight of metal that went through the furnace was 51 cwts. The material was subsequently rolled and passed on to the cartridge manufacturer, and made up into 0·303 bullet sheaths. Every detail that might interfere with the success of the experiments, or the reliance to be placed on the results of the test, was eliminated as far as one was able to foresee.

*(To be continued.)*

Tungsten and Molybdenum Steels.—A report issued by the French Societe Electro-Chemique du Giffre indicates that radical changes are taking place in the manufacture of special steels, and that the use of tungsten steel is increasing every day, fresh applications being continually investigated. Molybdenum is likely also to play an important part in the manufacture of special steels. Although the prices of wolfram and molybdenum are expected to decrease somewhat, it is practically certain that they will not return to pre-war levels.

# INTERNAL BOILER CORROSION.

By R. T. Strohm.

## Impure Water.

The corrosion of the plates and tubes of steam boilers can be traced to either impure water or electrical action. Of the two, the former is by far the more common cause, and its effects may be observed both inside and outside the boiler. The wasting away of plates and tubes by electrical action is confined to the water side of plates and tubes. In a general way, then, corrosion may be divided into internal corrosion and external corrosion, according as it takes place inside or outside the boiler.

Internal corrosion may be caused by the presence in the feed-water of one or more of the following substances: Chloride of magnesia, free acid, dissolved carbon dioxide or oxygen, grease, or organic matter.

The greater number of chlorides found in feed-water are not affected by the boiling of the water, but magnesium chloride differs from the others in that it is unstable and is decomposed, or broken up, by the heat. The decomposition of the chloride forms magnesium oxide and free hydrochloric acid, and the latter immediately attacks the iron and eats it away. If lime is present with the chloride of magnesia, the two act on each other and free carbonic acid is formed, in addition to the liberation of hydrochloric acid.

Free acids in the water fed to a boiler are sure to produce corrosion of the metal. Fortunately, they are less likely to be present than are the other materials that cause corrosion, except in the case of feed-water found in and about mines. In the latter case free acids are very apt to be found in the feed.

Water flowing in open channels and through the strata of earth absorbs air readily, and when the water is fed to the boiler, the air goes along. The constituents of this absorbed air are oxygen, nitrogen, and carbon dioxide. The nitrogen is harmless, so far as its action on the boiler is concerned, but the oxygen leads directly to corrosion. Alone, oxygen will have no effect on iron; but in the presence of carbonic acid it becomes a very active agent in producing corrosion. The carbonic acid attacks the iron, forming carbonate of iron; but the oxygen at once combines with the carbonate, forming iron hydrate and liberating carbonic acid. Of course, as soon as the acid is set free it renews its action on the iron, and the process of corrosion becomes continuous so long as there is free oxygen present to break up the carbonate formed.

## The Acidity Test.

The usual test for acidity of water is to note whether blue litmus paper will be turned red by the action of the water. But the amount of carbonic acid present may be so slight, in comparison with the volume of water, that it cannot be detected by the litmus test, and yet lead to extensive corrosion in the presence of oxygen, because of its repeated action in the manner just described.

Carbonic acid is very apt to be formed by the decomposition of organic matter in the feed-water. Such organic matter will be introduced into the boiler if the feed-water is drawn from a fresh-water creek that receives surface drainage, particularly during rainy seasons.

If animal or vegetable oils are introduced with the feed-water, corrosion is apt to result. These oils are sometimes used as adulterants in cylinder oils, and manage to get past the oil separator and the condenser, and so find their way into the boiler. When such oils are heated, they break up, forming glycerine and free acids, and the latter then attack the iron of the tubes and shell of the boiler.

Of course, there is one way of preventing internal corrosion, and that is to heat the feed-water so as to remove or neutralise all corrosive agents before the water is allowed to enter the boiler. But this method is not always feasible or economical. It has become the more common plan, therefore, to inject certain chemicals along with the feed-water and allow the reactions to take place inside the boiler.

## Remedy for Corrosive Acids.

The remedy for the presence of corrosive acids in boiler feed water is to render the feed strongly alkaline by the addition of alkaline salts. For example, if magnesium chloride is the troublesome ingredient because of its liberation of hydrochloric acid, caustic soda will neutralise the effect of the acid. Carbonate of soda would have the same effect, but there is some danger of its becoming a source of carbonic acid, which is corrosive in itself. To ensure that all acid is completely neutralised and thus rendered harmless, the water should be kept so strongly alkaline that it will change the colour of red litmus paper to blue.

If animal or vegetable oils are the cause of corrosion, the feed-water is treated with slacked lime, carbonate of soda, or caustic soda. In the presence of lime or soda the acids in the oils leave the glycerine and are thus neutralised. Mineral oils have no such acid action on iron, and care should therefore be taken to see that only mineral oils are used as cylinder lubricants.

Organic matter in feed-water may be removed by treating the water with alum, which will precipitate the foreign matter. The precipitated sludge can then be removed by settling or filtration.

## Electrical Action.

Electrical action, or electrolysis, is responsible for the corrosion of iron and steel in many instances. If a piece of iron and a piece of brass are placed in water that is even slightly acid, and are connected by an external wire, a current measurable by a galvanometer will be set up. The current will pass from the iron to the brass in the liquid, and as the action continues the iron will be eaten away. This is precisely what happens in the steam boiler. Brass valves and iron shells are in contact with the water and are connected, and galvanic action results. The iron is wasted away on the water side and the surface of the plate becomes pitted.

Now, if zinc and iron are used instead of iron and brass, as explained above, the current will pass from the zinc to the iron in the liquid, and the zinc will be eaten away instead of the boiler-plates, by galvanic action. This fact has led to the wide adoption of zinc as a preventive of corrosion of the iron. Slabs of zinc are suspended in the water of the boiler, but care is taken to see that they are in excellent metallic contact with the iron of the shell. Any galvanic action that occurs will then waste away the zinc, and the iron will be spared.

## Mill Scale.

The presence of mill scale on the plates or tubes of a boiler may result in corrosion through electrolytic action. Mill scale and clean iron have different positions on the electrical scale, and if the two are placed in contact with water that contains acid, an electric current is set up, and the iron is affected. To prevent corrosion from this cause, therefore, care should be observed to have the plates of a new boiler free from mill scale.

Where internal corrosion is prevalent, it is often found that the shell of the boiler is pitted over a band of some width at about the normal water level. The explanation of this corrosion is that air is carried into the boiler by the feed-water, and when the water becomes heated the air

bubbles rise to the surface. They are not able to break through the surface film at once, but are retained, and are then carried by the circulation into contact with the shell at the water line, where they adhere. The oxygen that they carry is then able to attack the plate, resulting in the formation of small pits. As the mater level fluctuates, the pitting occurs at slightly different levels, causing a band of corrosion all around the interior of the boiler.

A coating of graphite, it is claimed, will prevent pitting of boiler shells. It is made up into a paint, and a coating is applied to the interior surfaces of the boiler. To render it effective, however, the surfaces must be cleaned thoroughly, as by scrubbing with a wire brush, so that when the paint is applied it will cover all parts of the metal and will not peel The action of the graphite in preventing pitting is neither chemical nor electrical. It simply protects the shell by preventing the corrosive substances from reaching the iron. A paint suitable for this purpose may be made by mixing flake graphite and linseed oil; or fish oil may be used instead of linseed oil.—*National Engineer.*

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

### GERMANS IN BRITISH WORKSHOPS.

*To the Editor of "The Industrial Engineer."*

Sir,—At the moment when Mr. Bonar Law was announcing in the House of Commons that additional hospital ships had been sunk by the Germans application was being made here for employment for an interned German whom it was sought to bring back into British industrial life.

The application was made by a representative of the Friends' Emergency Committee, of St. Stephen's House, Westminster Bridge. To us it seems inexplicable that, while tens of thousands of alien enemies are still at large in London, and many others should be rounded up, the work of liberating men who, apparently for sufficient reasons have already been locked up, should proceed as if the Germans, as we know them to-day, were peace-loving people who could be trusted to act loyally as British citizens. What perhaps is most surprising is the statement of the Committee's representative that Lord Newton and the Home Office are specially interesting themselves in this work of liberating interned Germans. By all means let the Germans work and earn their living, preferably on the land, or on reclamation, forestry, or other work of national utility under proper supervision, but it seems unthinkable that they can be allowed to take positions in British engineering shops. It may be that the German resident in Britain is less vicious and less violent than the American variety which is specialising in the destruction of Transatlantic factories. Be that as it may, we could not think of asking our men to work side by side with German workmen, and we do not think they would care to do so at a time when many households in the kingdom mourn the loss of one or more of its male members. We should be glad enough to obtain additional expert workmen, but if we are ever to rid the country of alien influence now is the time to do it. Certainly we do not intend to re-introduce the alien elements into a business in which British workers have more than proved their ability to compete with the best that Germany can offer. It seems to us that the whole question is one which affects closely our national life and industry, and it is on this ground that we take the liberty of writing you.

Later.—Since writing the above we observe from the newspapers that German prisoners engaged planting potatoes in one of the principal market-gardening centres in Britain have been carefully removing the eyes from the tubers to make sure that no crop shall be gathered! Truly a most excellent class of workman for British workshops!—We are, sir, yours faithfully,

Barimar Limited
(Scientific Welding Engineers),
C. W. Brett,
Managing Director and General Manager.

# Trade Items, Notes, &c.

Mr. Clarence Brewer, sawmill engineer, writes us to say that owing to extensive increase of business he has been compelled to take larger premises for his works at 20, Stamford Road, Dalston, and Hertford Road, Dalston, N.L. Also that he has secured more convenient offices at 209, City Road, situated next door to the present offices. Communications should be addressed to 109, City Road, E.C. The telephone number remains the same.

Coke Oven By-Products in the United States.—Our American contemporary, *The Iron Trade Review*, notes with satisfaction that the United States iron and steel industry has been vigorously carrying forward of recent years the construction of coke plants of the by-product recovery type. It is estimated that the country is to-day producing pure or refined benzol at the annual rate of 30,000,000 gallons; pure toluol from 6,000,000 gallons to 8,000,000 gallons; and phenol from 25,000,000 lbs. to 30,000,000 lbs. In the midsummer of 1914 the American annual production of pure benzol was at the rate of 3,000,000 gallons; of toluol, 750,000 gallons; and of phenol, 120,000 lbs. In 1916 the country produced about 325,000 tons of sulphate of ammonia equivalent, compared with 183,000 tons in 1914. After the war much of the coal-tar products now going in some form to European battlefields will be diverted to peaceful purposes Furthermore, adds our contemporary, the American manufacturing efficiency will have been greatly promoted by the advantages which the by-product method of coke-making possesses over the bee-hive process.

The Brown Coal Deposits of Victoria.—The *Melbourne Age* states that the more knowledge the Minister of Mines acquires of Victoria's brown coal deposits, the more he becomes impressed with their potential value. At the opening of the new school of applied arts at the Working Men's College, Mr. Livingston said there were syndicates in Melbourne willing to spend £200,000 or £300,000 on establishing experimental works for treating the brown coal and ascertaining the value of its by-products. "The results of drilling for black coal had not been very encouraging, but there were great deposits of brown coal in Gippsland, as well as at Lal Lal and Laverton. Mr. Harper, city electrical engineer, informed him that the horse-power required for Melbourne industries in 10 years' time would be 100,000. We could not get the necessary fuel from our black coal fields, and unless we got it by some means, our industries would fail, as they would not be able to stand against New South Wales with its plentiful supplies of black coal. The Minister urged scientists and students to give special attention to investigation of the utility of brown coal."

The Magneto Industry.—At a meeting of the Aeronautical Society of Great Britain, on April 4th, Mr. A. P. Young delivered a lecture on "Magneto Electric Ignition on Aircraft." He said that without the high-tension magneto it was certain that the aeroplane would never have reached its high state of development, and it was reasonable to assume that the whole course of the war would have been different and much less in our favour. Prior to the outbreak of the war the number of high-tension magnetos produced in this country formed a negligible proportion of the total number being used for a variety of purposes, and through laxity on our part this most vital industry was allowed to develop in Germany. During the war the magneto industry in this country had developed at a really wonderful rate, and he thought it was agreed by those in a position to judge that the British magneto, as at present constructed, was the equal of the pre-war Bosch magneto emanating from Stuttgart. Developments now taking place would result in British manufacturers producing new types that would prove vastly superior to anything turned out of Germany in the past. He therefore pleaded that when the war was over British magneto manufacturers should be given full encouragement and support by the Government and the public, so that there might be established on a solid foundation a British magneto industry that would endure through the years to come—an industry producing magnetos and ignition apparatus for aeroplanes, motor-cars, and other purposes, of superlative quality and design, not surpassed by anything manufactured outside of these islands.—*Morning Post.*

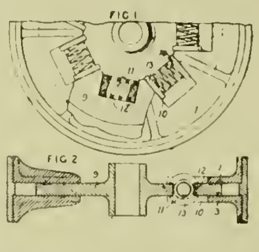
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### VEHICLE WHEELS, BELT PULLEYS, ETC.

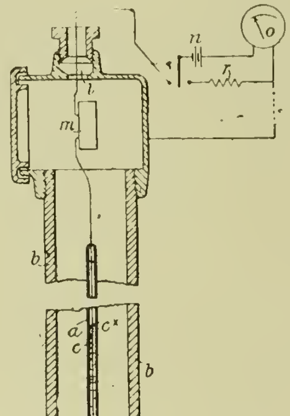
103,397.—G. K. GREEN, 171, Dalkeith Road, Edinburgh.—April 19th, 1916, No. 5,700.—Relates to vehicle wheels of the kind in which radial and circumferential movement of a floating rim is resisted by circumferential helical springs. A central disc 9 formed with rectangular apertures 12 near the periphery is



arranged to slide inside a rim formed of two spaced plates 1, 3 each having gaps 10 in the edge. The ends of the apertures and gaps register and are fitted with sliding plates 13, 14 between which helical compression springs 11 are arranged. The inner and outer walls of the apertures 12 engage notches in the plates 13, 14.

### INDICATING LIQUID LEVELS; PRESSURE GAUGES.

103,401.—H. N. URQUHART, "Clovelley," Essex Road, Gravesend, Kent.—May 1st, 1916, No. 6,201.—An apparatus for indicating the pressure of a fluid, or the depth of liquids, or for sounding purposes at sea, comprises a column of mercury cx in a tube $a$ communicating with a mercury chamber $d1$ covered by a flexible diaphragm $e$, the mercury being adapted by its movement along the tube to vary an electric resistance $c$ in circuit with an ammeter $o$ or other instrument, which may be graduated to read pressures or depths directly. An outer protective casing $b$ of



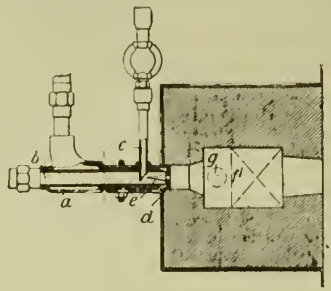
metal may form one of the terminals, and the resistance $c$ in the mercury tube is connected to a contact box $m$ in the upper part of the casing, which is fitted with a stuffing-box device $t$. The connections include a two-way switch $s$, by moving which the ammeter $o$ and battery $n$ may be put in circuit with a standard resistance $r$ to enable the ammeter to be adjusted for variations in voltage. The mercury tube may be of glass with a flange $a1$ held down by a screwed ring $f$, and the resistance $c$ may be a straight carbon filament of high resistance.

### OIL BURNERS.

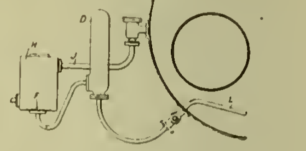
103,408.—W. A. RUSSELL and MANCHESTER FURNACES LTD., Globe Works, Ashton New Road, Manchester.—May 11th, 1916, No. 6,758.—Air under low pressure is supplied through passages $b$, $a$ so as to impinge on a vane-wheel $d$ supported at the end of the passage $b$, and oil is delivered by a pipe $c$ in the passage $b$, the oil-air mixture being directed by a cone $e$ on to the vane-wheel. The combustion chamber has a lighting-aperture $g$ and a cleaning and inspection door $f1$.

### STEAM GENERATORS.

103,414.—D. J. JENKINS, s.s. Akbar, Alexandra Dock, Bombay.—May 19th, 1916 No. 7,192.—A feed-water heater and circulator for a boiler comprises a mixing-vessel H, means to pump feed-water into such vessel intermittently, a hot-water supply pipe L fitted with an air chamber D delivering water from the lower part of the boiler through a non-return valve F to the vessel H, and a pipe J for discharging water from the vessel to the boiler.



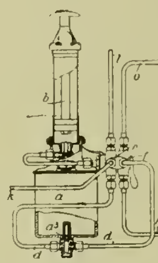
Patent 103,408.



Patent 103,414.

### INTERNAL-COMBUSTION ENGINES.

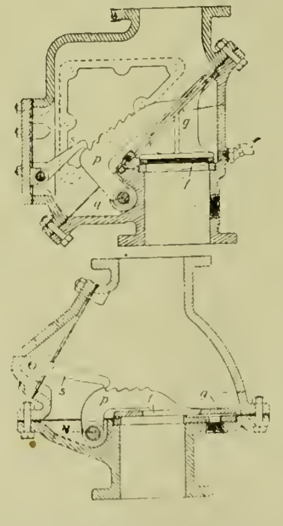
103,428.—F. H. ROYCE, E. W. HIVES, and ROLLS-ROYCE LTD., Nightingale Road, Osmaston, Derby.—June 26th, 1916, No. 8,969. Addition to 2,840/15.—In starting devices of the kind in which liquid fuel is sprayed into the induction pipe, the supply tank for the priming-device is not the float tank of the carburettor as described in the parent Specification. The supply tank $a$ feeds a **U**-shaped pas-



sage $d$ through a non-return valve $a3$, and an air-pump $b$ is used for forcing the fuel from this passage through either of the priming-pipes $o$, $p$. By rotating the valves $e$, $f$, the pump is cut off from the passage $d$ and put in communication with either of the pipes $l$, $k$, which may lead to the main fuel tank or any other tank where air pressure is required.

### FIRE EXTINGUISHING.

103,449.—MATHER AND PLATT, Park Works, Manchester.—(A. J. Loepsinger, Providence, Rhode Island, U.S.A.).—September 8th, 1916, No. 12,730.—A dry-pipe valve comprises an air valve $g$ and water valve $f$ arranged to close the waterway and to

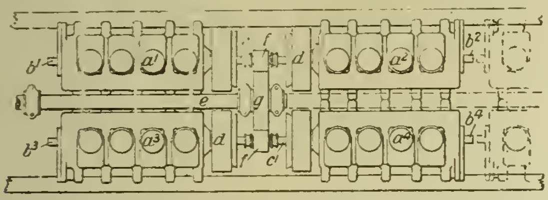


transmit pressure from one to the other when seated, and connected to a lever $p$ pivoted at $q$ outside the waterway so that the leverage on the air valve is greater than that on the water valve. The lever $p$ is serrated on the upper side and, when the valve is open, engages a latch $s$ to retain the valve against closure. Fig. 1 shows a form in which the two valves are of different area and mounted at an angle to one another. In a modification, the valves, instead of being rigidly connected,

are connected through a ball-and-socket joint. Fig. 2 shows a form in which the valves are situated in parallel planes, the valve seats being arranged eccentrically.

## MOTOR POWER PLANT.

103,444.—A. W. BOOTHROYD, Colne Lodge, Colne Road, Lexden, and A. G. MUMFORD LTD., Culver Street Engineering Works, Colchester, both in Essex.—July 31st, 1916, No. 10,787.—Internal-combustion engines are arranged in groups of four or multiples thereof, the units being arranged in two parallel pairs $a1$, $a2$ and $a3$, $a4$ having their respective crank-shafts $b1$, $b2$ and $b3$, $b4$ coupled to axially-aligned intermediate shafts $c$, $c1$ which drive a common transmission shaft $e$ through a single train of gearing $f$, $g$. To enable any number of motors to be put in or out of

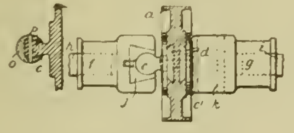


operation, clutches $d$, which may be of the combined friction and positive engagement type, are arranged as shown, or the spur-wheels $f$ may be connected by clutches to the shafts $c$, $c1$, which in this case are formed as extensions of the crank-shafts. A single reversing-gear may be provided on the transmission shaft, or a high-speed reversing-gear may be employed between the clutch of each engine and the intermediate shaft. For marine work, each group of engines is housed in a separate water-tight compartment, the control of the clutches and of the reversing-gear being arranged above the water-line.

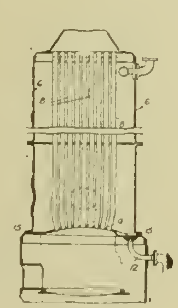
## INTERNAL-COMBUSTION ENGINES.

103,450.—C. J. GRACE, Tregrayth, Kenwyn, Truro, Cornwall.—September 8th, 1916, No. 12,752.—In the carburetter described in the parent Specification, fuel is supplied through capillary tubes, the number of which in action, as well as the supply of air, can be varied simultaneously. The improvement consists in mounting the tubes C in a sleeve valve D, which is actuated from the throttle-valve spindle H through links G, F, and has in its wall triangular air ports J which register more or less with trapezium-shaped ports K in the carburetter casing. The maximum area of the ports K may be varied by ports in a sleeve L, which may be adjusted angularly by an eccentric N on a spindle O. The tubes C have inlet apertures at different heights and pass through a plate B supported by the cover of the float chamber A.

Patent 103,450.



Patent 103,463.



Patent 103,501.

## UNIVERSAL JOINTS.

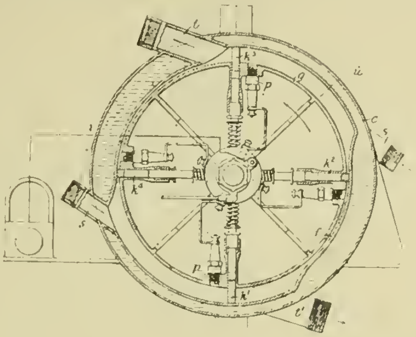
103,463.—A. L. JENNINGS, Northfield, Snelsins Lane, Cleckheaton, Yorkshire.—October 27th, 1916, No. 15,323.—Relates to couplings of the kind allowing universal and lateral movement of the shafts, in which one or more central disks carry cylindrical projections arranged at right angle engaging similar recesses in coupling blocks which may slide on the shaft ends. Cylindrical projections $c$, $c^1$, Fig. 3, are carried on dovetailed plates $d$ bolted into recesses in a central disk $a$, or in a pair of disks bolted together, or the projections may be formed integrally with the separate disks. The projections, which are arranged approximately at right angles, engage brass or other soft wearing pieces $j$, $k$ carried in blocks $f$, $g$ sliding on square or other polygonal shaft ends $h$, $i$. In the form shown in Fig. 5, the pieces $j$, $k$ are dispensed with, the projections being formed dovetailed in shape with the sides $p$ parallel or tapering along their length, and covered by a cylindrical sleeve $o$ of soft metal.

## STEAM GENERATORS.

103,501.—T. HUDSON, Birnam Lodge, Airdrie, Lanarkshire.—January 24th, 1916, No. 1,066.—In a boiler having vertical smoke tubes 8, and a shell 6 built up of circular sections, the lower tube plate 4 is flat or slightly dished and is so arranged that there is no water jacket around the combustion chamber, the boiler water space being entirely above the level of the firebox. The lower tube plate is slightly inclined towards the blow-down pipe 12, a tapering ring 15 being placed between the plate and boiler shell. Flattened recesses or steps may be formed in the tube plate to receive the tubes.

## ROTARY ENGINES.

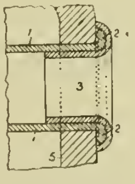
103,503.—I. TURNER, Fir Tree House, Rochford, Essex.—January 24th, 1916, No. 1,106.—The drum $g$ of a rotary internal-combustion engine, Fig. 2, carries spring-pressed outwardly sliding vanes $k^1$ . . $k^4$, each of which draws through an inlet $s$ a charge which is compressed by the following vane through the clearance $f$ between the drum and the casing, and fired by a sparking plug $p$ when the first vane reaches the line $u$. Exhaust takes place



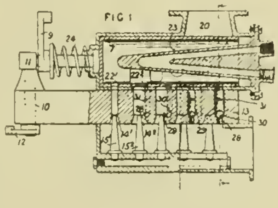
through an outlet $t$. A second unit with inlet $s^1$ and outlet $t^1$ may be arranged on the same shaft. A water jacket $c$ is provided. Instead of a number of sparking plugs being secured to the rotor, a single plug may be arranged in the casing. In a modification, Fig. 3, having the same working cycle, the outer casing $w$ is the rotor and carries the vanes $y$, while the inlet $z$ and outlet $z^1$ are formed in the stationary inner member $v$.

## SECURING TUBES TO TUBE PLATES.

103,506.—H. W. JOHNSON, Rainford Works, Rainford, and R. E. B. TREVOR, 7, Alexander Drive, Princes Park, Liverpool, both in Lancashire.—January 25th, 1916, No. 1,153.—A boiler smoke tube or the like 1 is secured to a tube plate 5 by forcing a protecting ferrule 3 into the tube, thus bending over the tube end 2 against the outer surface of the tube plate. The ferrule is inserted by means of a screwed bolt engaging with blocks at each end of the tube. The outer edge of the hole in the tube plate may be slightly smoothed or bevelled.



Patent 103,506.



Patent 103,520.

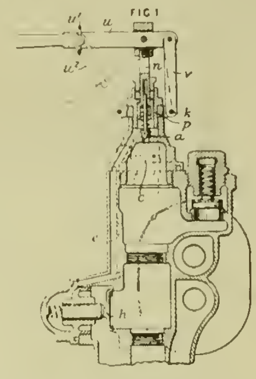
## INTERNAL-COMBUSTION ENGINES.

103,520. T. J. DISTURNAL, Belmont, King's County, Leinster, Ireland.—January 27th, 1916, No. 1,326.—A multiple-jet carburetter, in which a number of independent choke tubes are controlled by a common throttle valve moving directly over them, is provided with one or more additional air inlets, each provided with a ball or other gravity valve and controlled also by the common throttle valve. The invention is shown as applied to the carburetter described in Specification 6423, 1915, which comprises choke tubes $14^1$, $14^2$, etc., and additional air passages 28 formed in a block 13. Nozzles $15^1$, $15^2$, etc., project into the choke tubes, which, together with the additional air inlets, are controlled by a throttle valve 7 having ports $22^1$, $22^2$, etc., and an outlet aperture 23 and adjustable both angularly and axially by the lever 9 and by the lever 12, spindle 10, and cam 11 respectively. The additional air passages 28 are enlarged at 29 to accommodate a ball or other gravity valve 30, the lift of which is limited by a pin 31. A spring 24 controls the throttle 7 against suction which, when the engine races, tends to draw the valve forward and cut off the mixture through the choke tubes and the outlet 20. The block 13 may be of aluminium or other suitable metal, and may be separate from the casing, and the air inlets may be vertical or inclined.

## INJECTORS.

103,528.—R. G. BROOKE, Upton Grange, Macclesfield, Cheshire.—February 1st, 1916, No. 1,533.—Relates to injectors of the kind described in Specification 3321, 1909, wherein pressure from the delivery chamber, when the injector is at work, serves to close down the overflow valve, but which, at starting or re-starting, is prevented from acting on the overflow valve by a spring-weighted interposed valve loaded so as to be opened by a pre-determined pressure somewhat below boiler pressure. Means are provided for varying the load upon the intercepting valve, or to hold it in the closed position to prevent action by the delivery pressure upon the overflow valve. Fig. 1 shows the intercepting valve $a$ between the delivery chamber $c$ and the overflow valve $h$, loaded variably by a spring $k$, upon the upper end of which a sliding spindle $n$ may be pressed down by a hand-lever system $u$, $v$, or the end of the head $p$ in which the spindle terminates

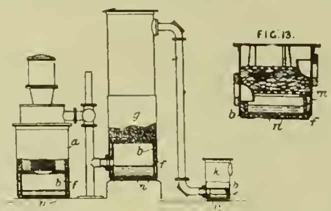
may be forced directly against the valve. A clamping screw $u^1$ in combination with a graduated slotted link $u^2$ enables the lever system to be adjusted. Alternative constructions are described in which the up-and-down movements of the spring and



valve-controlling spindle are effected by screw action, and in which a stop cock is arranged in the passage *e* for cutting off the delivery pressure.

### SUCTION-GAS PLANT.

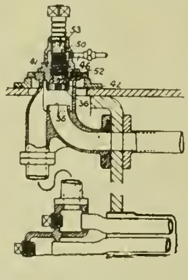
103,529.—A. R. BELLAMY and JAS. C. BELLAMY, Spittlegate Ironworks, Grantham, Lincolnshire. Feb. 2, 1916. No. 1,576.—In a suction-gas plant, the lower parts of the casings of the generator *a*, coke scrubber *g*, reservoir box *k*, wood-wool scrubber *m*, etc., are



provided with metallic linings *b*, and cement is filled into the spaces *f* between the linings and the casings. The linings may be in two or more sections, and spacing lugs *n* may be provided on the bottom of the lining, or such bottom may be omitted. The wood-wool scrubber may replace the reservoir box or be used in addition thereto.

### STEAM GENERATORS.

103,534.—G. H. WILLANS and E. S. LUARD, 41, Moorfields, London. —February 3rd, 1916, No. 1,663.—In a feed-water heater, or in a combined feed-water heating and boiler-water circulating apparatus for locomotive and other boilers, the water outlet is controlled by a valve formed with relief passages, so that when the valve is closed to cut off the flow of water into the



boiler, the relief passages place the heater in communication with the atmosphere. The valve 36 is shown applied to the heating and circulating apparatus described in Specification 4085, 1915. When the valve head 42 is screwed down on to the end of the boiler inlet pipe 35, the heater is open to a relief pipe 46 through radial passages 52, 53 and a longitudinal passage 50 in the valve stem. When the valve is open, the head is seated against the bottom of the valve casing 41. The outlet end of the relief pipe is carried to a position where it is visible to the engine driver.

IMPORTS OF ENGLISH COAL TO ITALY. *L'Union Franco-Italiano*, a weekly journal published at Nice in the two languages, states the imports of English coal to Italy last year show a decrease of 3,937,152 tons, or nearly half the total as compared with those of 1913. The quantity of coal exported from England to Italy during the last four years was respectively: 1913, 9,647,160 tons; 1914, 8,625,000 tons; 1915, 5,738,460 tons; 1916, 5,710,008

# INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

VOL. V.] MAY 22ND, 1917. [No. 135.

## The Industrial Engineer.

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CONTENTS.



# EDITORIAL.

## THE ENGINEERS' STRIKE.

OUR readers will remember that on the occasion of the engineers' strike at Barrow a few weeks ago we wrote very strongly in condemnation of the policy of a rank-and-file strike under the leadership, or at the instigation, of the shop stewards, giving as our reason that when agreements had been entered into with the Government, on the one hand, and the employers and employees on the other, the men should act through their properly-authorised executive at all times when a change in working conditions was thought to be necessary. This seemed to us such obvious horse-sense that it was not surprising to find our views emphasised by the Labour Minister, Mr. John Hodge, M.P., a few days after the issue of that particular number of the *Industrial Engineer.* The views we then expressed were in the best interests of the men themselves, and we know definitely that they were endorsed by a large number of the men who could see a little farther into the future than their confrères. It is therefore with profound regret and misgiving that we learned of the more general strike—which at the moment of writing seems likely to be settled—of engineers in which the shop stewards have again been to the fore, and the executives of the men's societies have for the second time in a few weeks been flouted. These circumstances seem to indicate a spirit of unrest which requires the strictest and most impartial investigation with a view of ascertaining the real causes and preventing a recurrence of lamentable disputes which are sapping the foundations upon which work has been carried on hitherto. We do not hold with those members of the community who are ready to coerce the men into doing the necessary work of the war without making any solid attempt to ascertain the rock-bottom causes which precede a strike. Danger lies in such methods, for it is beyond comprehension that men will strike when the conditions of actual military warfare are what they are, unless there is some adequate reason. It must be remembered that a very large proportion of the men have sons, brothers, or relations in the fighting line, and it is scarcely credible that they will lightly contribute to put them in added danger when every effort requires to be made to defeat the enemy. If the working conditions are such that the men think these dangers are secondary to their own trade grievances, then such conditions are in parlous case indeed. They would demand instant investigation, and a Government which had allowed them to get into that state would stand condemned in the eyes of all clear-headed men. We refuse, however, to think that the conditions are so bad. Nor do we think that they are even bad enough to warrant a strike at all. No conditions in engineering workshops to-day are a tithe as bad as those existing at the various fronts in which our gallant armies are fighting. Men cannot do more than risk life and limb in the bloody shambles which this devastating war has created. However hard an engineer works at the vice and at the lathe, and however long his hours, he is on velvet compared with his comrade in the trenches. His hours are limited and definite; he has a comfortable home to sleep in while his prototype in France is under conditions as bad as it is possible to be; and he is, moreover, at work, so to speak, when asleep. The pros. and cons. of the case could be extended indefinitely, but surely they are patent to everyone.

Nor is there any justification to be found in the statement that the men are fighting the industrial battles of their brothers at the front. There are no industrial battles at all comparable with those on sea and land at the present time. There is no room for industrial battles at the present juncture, and they ought to be unthinkable while the Hun remains unbeaten in the field. Whatever grievances exist are capable of rectification or modification by properly-

*(Continued on page 316.)*

# THE APPLICATION OF COAL GAS TO INDUSTRY IN WAR TIME: ITS NATIONAL IMPORTANCE.

By Horace M. Thornton, M.I.Mech.E.

(*Concluded from page 286.*)

A gas-heated lead-bath furnace for annealing aeroplane stream line wires is now seen on the screen. The furnace is 15 ft. long and is of the down-draught type. In mentioning aeroplanes, another interesting use for gas comes to mind—viz., for heating the dope room by radiators, as seen by the photograph (Fig. 9). This room has to be maintained at a high temperature to dry the aeroplane wings, etc. The next illustration shows numerous aeroplane parts spread out for drying, and the British identification discs may be seen. In this factory there are fixed 80 of these gas-steam radiators.

Although I have by no means exhausted the use of gas furnaces for steel, I think the other operations which will occur to you are represented in one way or another in the examples I have given. We will, therefore, now pass to the non-ferrous metals, aluminium, etc.

### Gas in the Non-Ferrous Metal Trades.

First, the melting of brass, copper, aluminium, cupro-nickel, etc., is being accomplished by gas in ever-increasing quantities for the manufacture of rifle and machine-gun cartridge cases, shell cartridge cases, driving bands, fuses, etc.

The next slide shows melting furnaces, not in an industry peculiar to war time, but possessing more than a passing interest—viz., the silver and bronze melting-house at the Royal Mint, where gaseous fuel has shown an economy over coke in respect of output, cost of fuel, cost of graphite goods, and cost of labour. The next slide is a photograph of a battery of 12 130 lb. high-pressure-gas-heated pit furnaces used for the production of 100 lbs. billets.

The next photograph is a battery of six high-pressure-gas-heated furnaces for melting aluminium.

Gas furnaces are also employed for heating the brass billets for extruding into the rod, as well as for heating up ingots to be rolled into billets and subsequently into strips. The first slide on this subject shows part of a suite of 11 furnaces for heating brass billets. Thirteen thousand per day are dealt with in these eleven furnaces.

The next slide is of a different type of furnace for a similar purpose. This, as will be at once apparent, is of the inclined type, the billets gradually rolling down as the sufficiently-heated ones are withdrawn. This work has been largely taken up in the Midlands by manufacturing silversmiths, whose plant was readily adaptable, and who found gas furnaces an immediate and convenient means of providing the necessary additional heat treatment. Our next slide illustrates four furnaces, fitted with endless chain conveyors for heating up brass billets before pressing (Fig. 10). Each of the trays which you can distinguish takes twenty minutes to travel through the furnaces, at the end of which time the heating is completed.

There are numerous other brass parts which receive heat treatment in gas furnaces, but we must pass on to copper. The picture presents us with a view of part of an installation of furnaces, each 12 ft. long, for annealing copper blanks prior to pressing or drawing and cutting into small sections for driving bands. After each heating operation (five in all are necessary) the metal is quenched in the tanks seen in the foreground. The bands themselves are heated in gas furnaces prior to their use.

The next photograph illustrates the annealing of rifle cartridge cases prior to the stamping and drawing processes. Another gas operation is seen on the next slide in connection with the rifle cartridge in the annealing of cupro-nickel sheets before breaking down, rolling and stamping or drawing into sheath for the bullet (Fig. 11).

Finally, before we leave the subject, it will be interesting to see one of the erecting shops in a large works engaged in the manufacture of gas furnaces (Fig. 12). Accuracy and control of temperature being always required of gas furnaces, it is essential the manufacturer should know exactly what his furnaces can do with different materials, and the

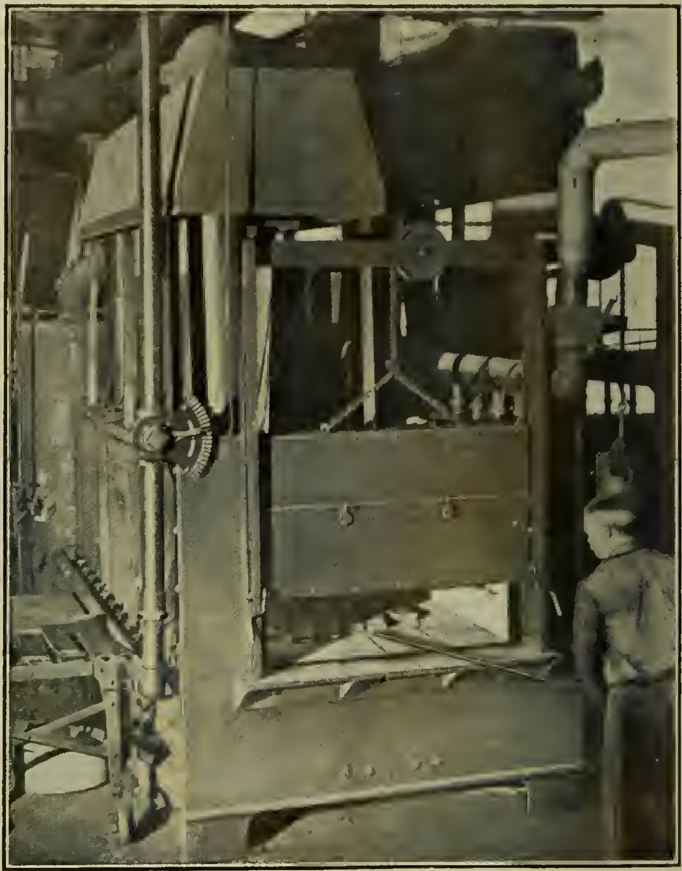


Fig. 11.—Oven Furnace for Annealing Cupro-nickel.

next picture shows part of a test room with blower, pyrometer outfit, etc., in the same establishment (Fig. 13).

I do not venture to claim that this recital of the uses of gas during the last two years for the production of munitions is anything like complete. Some of the more familiar have been omitted owing to the exigencies of time, while it is certain that very many applications of gas are being practised which have not come within the scope of one's own observation.

The extent of the increase in the use of gas for industrial purposes during the past two years can be best demonstrated by the consumption recorded by the gasworks in industrial towns. By the kindness of the respective gas engineers I have been furnished with the remarkable figures given showing the consumption for the last complete year of peace, and for the year ended December 31st last.

Coming to individual factories, by the courtesy of the Engineer of one of the largest gasworks in suburban

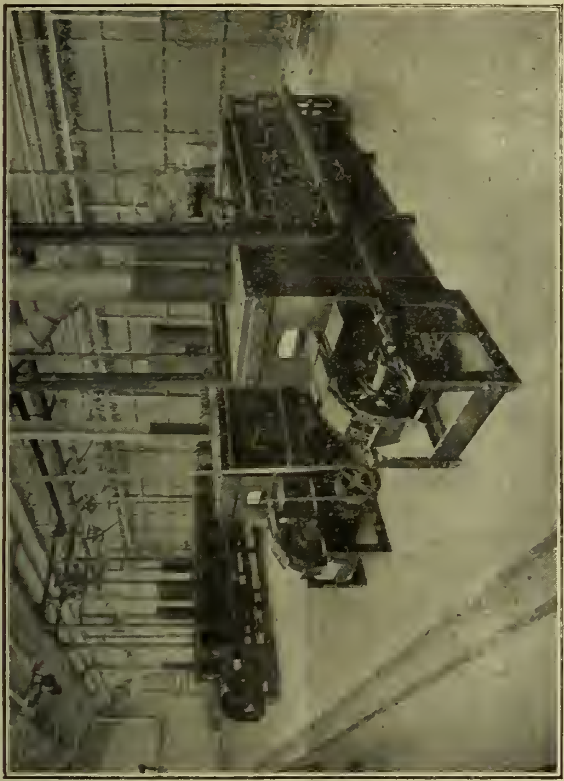


Fig. 10.—Four Belt-driven Conveyor Furnaces for Heating Brass Billets.

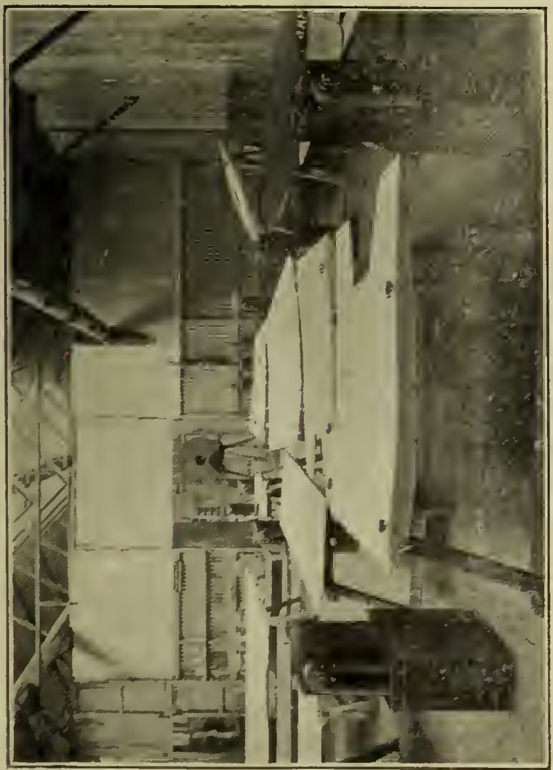


Fig 9.—Aeroplane Factory, showing Gas Steam Radiators for Maintaining High Temperatures.

London, I am able to give the figures of consumption, and the increases cannot fail to arrest attention.

Fascinating as this subject is, and full of interest to all who love to mark the stages in the development of indus-

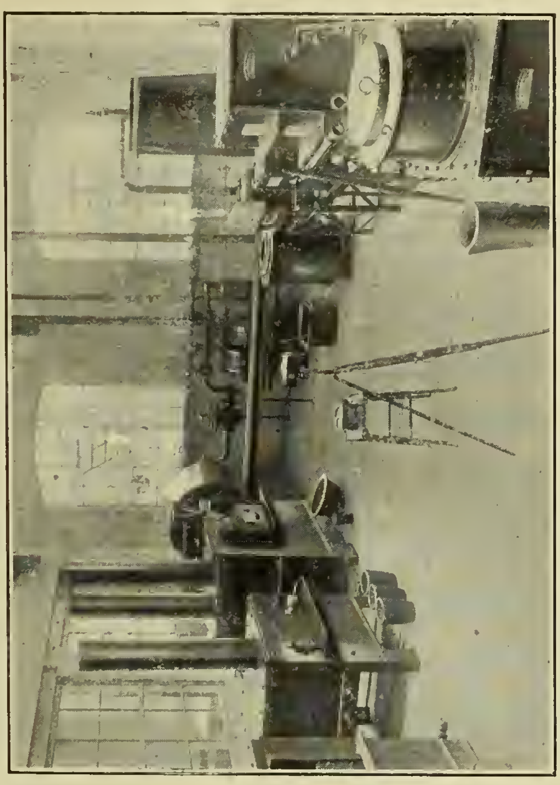


Fig. 13.—Corner of Furnace Test and Demonstration Room.

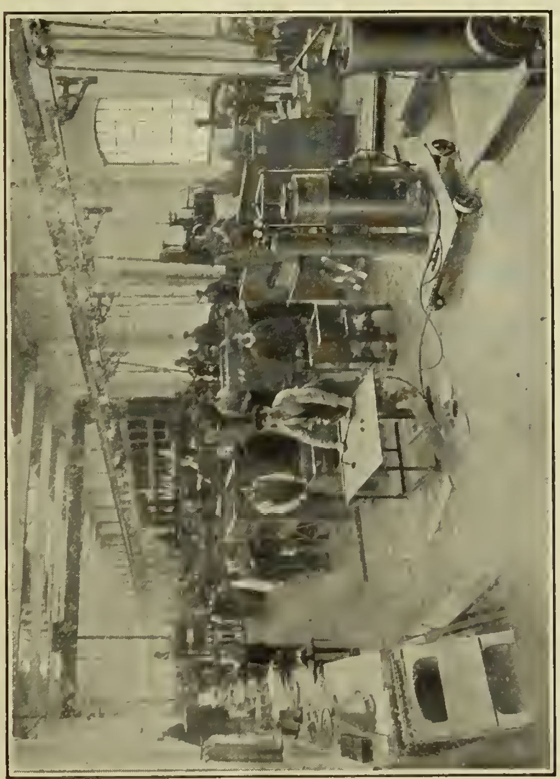


Fig. 12.—Part of the Richmond Gas Stove and Meter Company's Furnace-erecting Shop at Warrington.

tries, I must not linger, as I wish to call attention to other and equally important uses of gas in industry.

Gas Consumption for Manufacturing and Power Purposes in Eight Industrial Towns.

| | District. | Annual Consumption for Industrial Purposes. 1913. | 1916. | Percentage Increase. |
|---|---|---|---|---|
| | | Cubic ft. | Cubic ft. | |
| A | Midlands ...... | 110,707,000 | 174,167,000 | 57 |
| B | ,, ...... | 327,047,700 | 420,490,600 | 28 |
| C | Yorkshire ...... | 10,760,809 | 21,583,700 | 100 |
| D | North-East .... | 187,473,300 | 321,841,800 | 72 |
| E | ,, .... | 650,000,000 | 1,650,000,000 | 154 |
| *F | Midlands ...... | 1,901,392,000 | 3,500,000,000 | 84 |
| *G | ,, ...... | 65,882,200 | 140,000,000 | 112 |
| *H | North ......... | 720,032,300 | 1,155,461,810 | 64 |

* These figures are to March, 1913, and (estimated) to March, 1917, in each case.

Gas Consumption of Nine Typical Factories on War Work.

| | 1913. | 1916. | Percentage Increase. |
|---|---|---|---|
| A ...... | 3,618,300 | 15,579,000 | 330 |
| B ...... | 3,631,400 | 19,407,200 | 434 |
| C ...... | 5,202,800 | 9,845,100 | 89 |
| D ...... | 4,944,900 | 14,836,900 | 200 |
| E ...... | 1,187,600 | 40,456,000 | 3,314 |
| F ...... | 818,500 | 8,314,900 | 923 |
| G ...... | 23,390,400 | 52,043,500 | 122 |
| *H ...... | .... | 111,407,200 | .. |
| *I ...... | .... | 40,000,000 | .. |

## Welfare Work in Factories.

In the period of reconstruction and readjustment that will follow the war many problems will call for solution. Numerous views have already been expressed. Books, almost without number, have been published, and almost every day brings a fresh contribution. It would not be relevant to say anything on the subject to-day, except in respect of two points on which I think we shall all be agreed—viz., the desirability of improved relations between Capital and Labour, and the supreme need in the country's interest for continuing the high level of productivity which the last two years have witnessed.

One of the outstanding and most remarkable features of this generative time has been the extraordinary growth of what is known as "Welfare Work" in factories. Such marvellous success has attended its expansion that there is no doubt of its substantial contribution to the solution of the two problems I have mentioned.

The Ministry of Munitions, under the inspiration of Mr. Lloyd George, early recognised its value, and appointed a special committee "to consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the personal health and physical efficiency of workers in munition factories and workshops."

This committe has issued memoranda, to the number of fourteen, of a most practical character, and every possible kind of guidance and assistance has been provided for employers who desire to improve the working conditions of their men and women, and to secure their highest efficiency, and consequently their full productivity, for the nation's need. Arising out of the recommendations of this committee, and recognising the need for co-ordinating and directing the beneficent intentions of employers, an important adjunct to the Ministry of Munitions is now a Welfare Department, controlled until recently by that eminent sociologist, Mr. B. Seebohm Rowntree, who is now succeeded by Dr. E. L. Collis. It is of good augury for the future that the largest employer in the land—the Ministry of Munitions—thus recognises its responsibility for the welfare of its workers. May I quote the Prime Minister's own words?

"I cannot insist too strongly on the importance of this movement. It helps to secure a larger and speedier output of munitions; it preserves the health and the happiness of the workers; it relieves the harassed employer of needless strain.

"It is a strange irony, but no small compensation, that the making of weapons of destruction should afford the occasion to humanise industry. Yet such is the case. Old prejudices have vanished, new ideas are abroad. Employers and workers, the public and the State, are all favourable to new methods. The opportunity must not now be allowed to slip. It may well be that, when the tumult of war is a distant echo, and the making of munitions a nightmare of the past, the efforts now being made to soften asperities, to secure the welfare of the workers, and to build a bridge of sympathy and understanding between employer and employed, will have left behind results of permanent and enduring value to the workers, to the nation, and to mankind at large."

Welfare work is not altogether a new thing in this country, nor in America. Successful attempts, some on a scale as elaborate as the best we know to-day, were made many years ago; but it is only recently that it has attained great prominence.

Its benefits to the employer were seen to be as pronounced as to the employee. Care for the health and well-being of the worker created a greater productivity, and enabled the enhanced output to be maintained over a period of almost unlimited extent.

The definition of welfare work given by Miss Dorothea Proud in her recent book is:—

"Welfare work consists of voluntary efforts on the part of employers to improve, within the existing industrial system, the conditions of employment in their own factories."

Numerous, indeed, are the measures which fall within the scope of this definition, and probably no one factory can yet be found which has embraced them all. It includes a carefully-designed factory, with adjacent open spaces given to gardens or recreation grounds; good ventilation, heating, drainage and lighting. Walls and floors and machinery have to be considered as rendering possible a constant state of cleanliness; due regard has to be had to the number of workpeople per room or shop; machines have to be effectively guarded against accidents; provisions have to be made for first aid and for ample escape in case of fire; lavatories and sanitary appliances should be commodious and readily accessible. Swimming baths and gymnasia come within the wide limits of this new principle in industrial organisation; while, most important of all, there is the dining-room with its kitchen. Then there is the health of the workers to receive consideration; and doctors, nurses, and dentists are employed. Arrangements are made for the reception of employees in convalescent homes and holiday homes. Facilities are provided for and encouragement given to the workers' recreations and hobbies, both outdoor and indoor. Still within the definition of welfare work come the housing question, and that of the daily transport of the workers from their homes to the works. Still wider fields for welfare work are to be found in "after school"

education of boys and girls over the school-age limit; the technical education of young employees, with the consequent regulation of their hours of work; provision for mental development of employees by the institution of libraries, reading clubs, bands, singing classes, etc.

### The Industrial Canteen.

With many of these things we are to-day concerned in our consideration of the national importance of gas in war time; and probably ranking primarily in importance and pivotal to all the other schemes is the question of feeding the worker. This introduces the industrial canteen.

To quote one of the memoranda issued by the "Health of Munition Workers' Committee" previously referred to:—

"There is now an overwhelming body of experience which proves that productive output in regard to quality, amount, and speed is largely dependent upon the physical efficiency and health of the worker. In its turn such physical fitness is dependent upon nutrition."

Ordinarily there are many obstacles to workers securing this adequate nutrition. Many, probably most, workers must have their meals away from home; many have to work on night shifts. The common method formerly in vogue was for the worker to bring from home food prepared for eating. This necessarily limited the choice of food; it was cold, and likely to be stale. When the weather was warm or the workshop hot it readily underwent deterioration. An advance on this crude plan was for the employer to provide facilities for warming up food brought from home. In some districts, of course, public-houses and dining-rooms are available outside the works. But even in these cases the accommodation is not always adequate, and frequently the conditions are far from satisfactory. To meet the problem, therefore, employers have established workpeople's dining-rooms or industrial canteens in or near the factory itself. The Health of Munition Workers' Committee states:—

"This practice has abundantly justified itself from a business and commercial point of view; and in the opinion of the Committee the hime has come for a large extension of this method."

The first Minister of Munitions realised that the development of canteen provision on a large scale at numerous munition works would require the encouragement, guidance, and assistance which only a Government Department could afford. At his request the duty was undertaken by the Canteen Committee of the Central Control Board (Liquor Traffic), who have set up the necessary machinery for advising employers as to the design, equipment, and management of canteens. Arrangements have been made by which in certain cases controlled employers are enabled, with the approval of the Committee to meet the capital cost of canteens from profits which would otherwise have accrued to the State under the Munitions of War Act, 1915.

Canteens, as in other forms of welfare work, naturally range from the simple provision of a separate room in which the workers may eat their own food to an elaborate scheme of a complete dining-room. We are chiefly concerned to-day with the kitchen, the equipment of which with the most suitable apparatus is a matter of utmost importance.

Food must be well cooked or complaints will naturally soon be voiced. The cooking must economise and not waste the food, since the most stringent care is necessary to secure the utmost value owing to the comparatively low prices that must be charged, and particularly now that our food supplies are so costly and need to be carefully conserved. The cost for fuel must be as low as possible; and the whole work must be performed with a minimum of labour. It was doubtless these considerations that led the Committee on the Health of Munition Workers to state: "Where gas in sufficient quantity is available, gas cooking is usually preferred on account of cleanliness, efficiency, and saving of labour."

*(To be continued.)*

## BEARING LUBRICATION.

By Boynton M. Green.

*(Continued from page 287.)*

### The Journal.

The journal was a piece of mild steel, ground carefully to a diameter of 3·244 in., giving a running-fit allowance of 0·0035 in., or about 0·001 in. per inch of diameter. On each end of the journal was fitted a cast-iron flywheel, weighing about 67 lbs., secured by a nut. The total weight of the assembled journal, flywheels, and nuts was 165·5 lbs., making a nominal load on the bearing of 7·275 lbs. per square inch of projected area. The whole apparatus was mounted on two parallel lathe beds, and three lathe heads with four-step pulleys were utilised for the drive. The usual overhead countershaft drove the first lathe head, which drove the second head by a short piece of shaft and dogs. The second head drove the third by a short belt and tightener pulley. It was found necessary after several preliminary trials to introduce the tightener, so that the second belt could be used for gradual acceleration of the heavy rotating mass. The third head drove the test journal by a piece of ¼ in. steel shaft about 2 ft. long. As this flexible drive rod was loosely connected by a dog to the lathe head and by a cotter pin to the journal, it is fairly certain that no external deflecting load was applied to the latter. With the drive arranged in this way, 16 speeds were possible, but as all the cone pulleys were of the same design, some of the speeds were duplicated, so that only six speeds could be used.

With this apparatus it would be possible to vary the bore allowance by starting with a very small allowance and then grinding down the journal to give larger allowances. This procedure was contemplated when the apparatus was designed, but lack of time prevented tests with more than one allowance. To locate the position of the journal with relation to the bearing, three micrometers of a design similar to Kingsbury's were used. The micrometers and journal were placed in the primary circuit of an induction coil with a battery, and a telephone receiver was connected to the secondary of the coil. With Kingsbury's apparatus it was only necessary to mount one micrometer in the bearing, because his bearing was a simple cast-iron cylinder, so supported that it could be rotated about its own axis, thus bringing the micrometer into any position desired. His method was to locate the point of nearest approach and read the micrometer, calling this the zero reading. Then the bearing was rotated 180 deg. and another reading was taken. Half the difference between the zero reading and the second reading gave the radial distance between the axis of the bearing and the axis of the journal, and the angular displacement was read from graduations on the end of the bearing cylinder.

In the present experiment the bearing could not be rotated, so it was necessary to use three micrometers spaced 120 deg. apart around the bearing in a plane through its centre and perpendicular to its axis. The moving part of the micrometer consisted of a ½ in. steel rod hardened at

the contact end and threaded 40 threads per inch at the other end. To the threaded end was clamped a pointer $3\frac{1}{4}$ in. long, which served both to turn the rod and to indicate the reading. The rod was carried in a brass sleeve threaded to receive it, and electrically insulated from the bearing by a fibre bushing pressed on to the sleeve. The graduated scale was carried on an arm clamped to the top of the brass sleeve. This arm also carried a binding post for the electrical connection. The whole micrometer was held in place in the bearing by means of a brass collar which screwed down over the tapered fibre bushing.

The micrometers were calibrated by screwing them into a ring and then screwing down the micrometer point to touch a standard inside micrometer. The experimental micrometers were graduated in this way to thousandths and the ten-thousandth divisions were laid off from these major divisions. Micrometers 1 and 3 were graduated for a total of three thousandths, and micrometer 2 was graduated over a range of six thousandths. Before any test readings could be taken, it was necessary to set the micrometers to zero, *i.e.*, bring the micrometer points flush with the inside surface of the bearing brass by placing inside the bearing a sector cut from a polished iron ring which had been ground to the exact diameter of the bearing. The zero readings of all the micrometers were checked after every three or four test readings.

### The Character of the Runs.

The runs were made short purposely, usually under two minutes, to eliminate the temperature factor as far as possible. A long run was made at a constant speed to obtain some information concerning the influence of temperature on the position of the journal relative to the bearing, but the micrometer readings showed that the bearing itself was expanding very rapidly due to its thin section, so this investigation had to be abandoned. From 10 to 15 readings of each of the micrometers were taken at each speed, and the most consistent of the readings at each speed were averaged to obtain the final experimental data which are given in Table I.

TABLE I.—Distance Between Axes.

| Average Experimental Data. | | | | | Results. | |
|---|---|---|---|---|---|---|
| $V$ Ft. per Min. | Temp. deg. Fahr. | Micrometer Readings. In. | | | Axial Dist. In. | Angle. |
| | | 1 | 2 | 3 | | |
| 0 | .. | 0·0002 | 0·0035 | 0·0002 | 0·00175 | 90°00′ |
| 196 | 58 | 0·0001 | 0·0026 | 0·0006 | 0·00158 | 80°45′ |
| 306 | 66 | 0·0003 | 0·0025 | 0.0004 | 0·00153 | 88°10′ |
| 511 | 66 | 0·0003 | 0·0025 | 0·00065 | 0·00142 | 82°00′ |
| 817 | 78 | 0·0002 | 0·0023 | 0·0005 | 0·00134 | 83°00′ |
| 1224 | 70 | 0·00025 | 0·0021 | 0·0004 | 0·00125 | 86°05′ |
| 2042 | 80 | 0·0002 | 0·0020 | 0·0006 | 0·00113 | 77°40 |

In determining the mean thickness of oil film from the results, the following approximations were made: (*a*) that the loaded portion of the film was that below a horizontal plane through the centre of the bearing; (*b*) that the thickness of the film at this plane and on each side of the journal was equal to the radial bearing allowance; (*c*) that the mean thickness of film was the average of the thickness at this plane and the minimum thickness of the film. The minimum thickness of film is the radial allowance minus the distance between the axes of the journal and bearing. Making use of these approximations the resulting values of mean thickness of film are given in Table II.

TABLE II.—Mean Thickness of Oil Film.

| $V$ | Distance between Axes. | Min. Thickness Film. | Mean Thickness Film. |
|---|---|---|---|
| 0 | 0·00175 | 0 | 0·000875 |
| 196 | 0·00158 | 0·00017 | 0·000960 |
| 306 | 0·00153 | 0·00022 | 0·000985 |
| 511 | 0·00142 | 0·00033 | 0·001040 |
| 817 | 0·00134 | 0·00041 | 0·001080 |
| 1224 | 0·00125 | 0·00050 | 0·001125 |
| 2042 | 0·00113 | 0·00062 | 0·001185 |

The general equation of the curve plotted from these results is

$$y = b + c^{a}\sqrt{V} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $y$ = mean thickness of film in inches
$b$ = one-half the radial allowance
$c$ = constant dependent on allowance and possibly on viscosity
$a$ = constant dependent on viscosity and possibly on allowance
$V$ = surface velocity of journal in feet per minute.

By translating the horizontal axis of the curve the constant $b$ is eliminated, and the equation becomes

$$y = c^{a}\sqrt{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From the experimental curve the values of $c$ and $a$ were found to be

$$c = 0{\cdot}0000049, \quad a = 1{\cdot}8$$

and the resulting empirical equation is

$$y = 0{\cdot}0000049^{1{\cdot}8}\sqrt{V} \quad . \quad . \quad . \quad (3)$$

As to the application of the empirical equation in the general equation for bearing lubrication it may be said that it may be used directly for conditions of the same allowance and a lubricant having the same viscosity. For other allowances and lubricants the change of $c$ and $a$ cannot be stated definitely. It can be said in general that $c$ will change with some function of the allowance and $a$ with some function of the viscosity. It is also possible that $c$ may be affected by the viscosity and $a$ by the allowance.

The oil used during the experiment was an ordinary mineral oil known as Vacoline manufactured by the Standard Oil Co. Its viscosity was given by the Engler viscosimeter at 11·0 at 20 deg. Cen. and 2·95 at 50 deg. Cen. compared with water at 20 deg. Cen., which gave a specific viscosity of 38·9 at 20 deg. Cen. and 8·7 at 50 deg. Cen.

*(Concluded.)*

## METAL MELTING AS PRACTISED AT THE ROYAL MINT.

By W. J. Hocking.

*(Continued from page 292.)*

### Fuel Supply and Combustion.

Experience gained with the use of gas fuel in the temporary gold-melting house, to which reference has already been made, pointed to the desirability of securing a liberal supply of gas at a constant pressure. The supply of gas under these conditions was undertaken by the Commercial Gas Company, and a 12-in. street main was laid to the meter-house, where four meters, each of 1,000 light capacity, were installed, one to act as a reserve. From the

meter-house a 9-in. service main supplies the Melting Houses direct, and the consumption of gas in melting operations is readily ascertained.

In the large house (Fig. 2) the gas is delivered at the furnaces through a 6-in. service pipe at a steady pressure of 3 in. of water at the furnace. As the total consumption of the 16 large furnaces is about 15,000 cubic feet per hour, the provision for delivery is well in excess of the requirements. An ample reserve is considered essential to uniformity in results.

Three rotary blowers of the Reichhelm type obtained from the American Gas Furnace Co. are used to supply air for the burning mixture (Fig. 2). Each blower is capable of delivering 36,000 cubic feet of free air per hour at $2\frac{1}{2}$ lbs. pressure. All the pressure-blowers are motor-driven and two are coupled to feed the larger battery of ten furnaces. The maximum horse-power required to supply air under pressure for the whole of the furnaces in the large room is 45.

The air and gas are supplied by pipes laid below the ground level in a trench running parallel with the back of the furnaces. The sizes of these pipes are sufficiently large to admit of one or more furnaces being thrown in or out of action without disturbing the steadiness of the supplies of the remainder; that for air is 9 in. and that for gas is 5 in. to the larger battery, and 4 in. in diameter to the smaller. Connecting pipes from each of the two services are attached to a horizontal girder for support, and conduct the air and gas into a mixer devised by Brayshaw. A sectional drawing is shown by Brame,* but the pressures for gas and air respectively stated thereon do not correctly describe the Mint working conditions, which are 3 in. for gas and $2\frac{1}{2}$ lbs. for air. Check gauges are in use to determine whether these pressures are obtained at the furnaces.

Fig. 5A is a sectional elevation of the furnace, showing the crucible, muffle and cover, the gas and air pipes with nozzle and burner brick in position, and the main flue with its connections.

Fig. 5B is a back elevation, showing the gas and air pipes with quadrant taps, and the girder support.

Fig. 5C is a plan of two furnaces without their covers, each containing a crucible. One shows the top view with flue, and the other the bottom with nozzle and burner brick.

The admission pipes to the mixing chamber are governed by valves, the levers of which move over a graduated quadrant. With well-constructed taps of this description the supply of gas and air can be regulated with precision. In the course of a heat these supplies require adjustment as the temperature rises in the furnace.

From the mixing chamber the gaseous fuel passes through a right-angled elbow pipe, $2\frac{1}{2}$ in. diameter, to the furnace. To adjust the length of flame to the capacity of the furnace and secure greater melting efficiency, the internal diameter of this pipe was reduced at its extremity to $1\frac{3}{4}$ in. The method of inserting the nozzle of the burner into the wall of the furnace, illustrated in Fig. 6, is the one yielding most satisfactory results. This method, which is regarded as essential with this class of furnace to an economical use of gas-fuel, was gradually evolved in the Mint, and was finally adopted in May, 1912, as the result of a series of successive modifications.

An 8-in. end-piece, screwed in position and having a diminishing bore, forms the nozzle (Fig. 6), which is increased to 4 in. in outer diameter at its extremity, and consequently presents a thickened ring of iron to the firebrick. It is easily detached and renewed in the event of corrosion or partial fusion. It may be mentioned here that the effective combustion of the gaseous fuel appears to be aided and the amount of noise reduced by the use of pipes and connections with a perfectly smooth interior. To maintain this condition the mixing chamber and the delivery pipe to the furnace are periodically removed and cleansed from any accumulations of deposit.

The ignition hole of the furnace consists of a perforated firebrick of special shape, as shown in the sectional drawing given in Fig. 6. A circular recess, 4 in. in diameter, at the back of the block, which is $9\frac{1}{8}$ in. square, receives the iron nozzle, which fits the recess closely, and is surrounded by asbestos packing, well rammed in. The comparatively large block of firebrick serves to keep

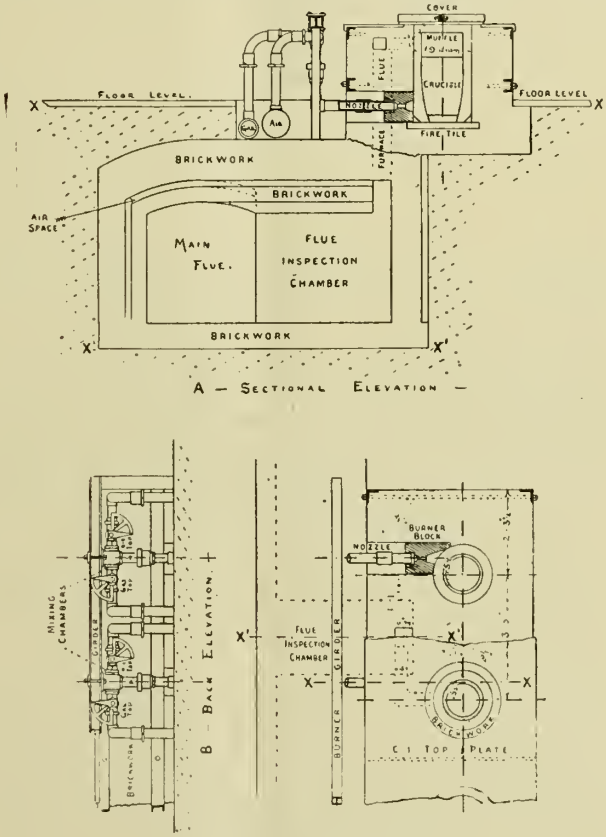



Fig. 5.—Gas Melting Furnace.

the nozzle relatively cool. At the bottle-neck the inlet is $1\frac{3}{4}$ in. in diameter, corresponding with the bore of the burner. The passage then opens out at an angle of 30 deg. into the well of the furnace, where ignition takes place.

The burner block is built into the brickwork, and is set to one side of the horizontal axis of the furnace well in a position to induce the flame to pass between the crucible and the side of the furnace without impinging upon either.

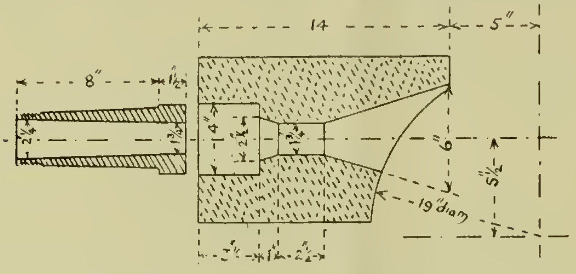
The crucible, which is of the Morgan Salamander type and of a special mixture adapted for use with gas fuel, is placed centrally in the furnace upon a graphite stand, 10 in. in diameter and $2\frac{1}{4}$ in. thick.

A plumbago muffle or collar, 8 in. deep, rests on the crucible to increase its initial capacity, but no cover is used for the charge during melting in the case of silver and the baser metals. About 3 in. clear space is allowed round

* "Fuel: Solid, Liquid, and Gaseous. Arnold, 1914. Fig. 31, p. 200.

the crucible at its greatest diameter to admit of the lowering of the tongs which lift it from the furnace for pouring. When the furnace is closed the top of the muffle is within 2 in. of the cover.

The gas flame on leaving the ignition hole travels round the crucible in an upward double spiral. The best results in economy and efficiency are obtained when combustion is complete in the furnace itself, no flame being emitted under the furnace cover nor carried into the flue aperture. To compensate for the lengthening of the flame which takes place as the temperature in the furnace rises during the progress of the melt, the supply of gas and air is regulated




Gas-burner Nozzle. Firebrick Burner Block.

Fig. 6.

by means of the quadrant taps already mentioned. Similar adjustment to maintain the correct mixture becomes necessary in the event of any variation of the gas or the air from normal pressure.

The flue aperture is 4 in. by 2 in. in sectional area, with its axis 5 in. below the iron covering plates, and opens into a horizontal duct leading from the furnace to a vertical shaft, 6 in. square, which serves for two furnaces. This shaft is connected with the main flue, constructed below the floor level. The main flue (Fig. 5a), which runs parallel with the line of furnaces, is 3 ft. by 3 ft. in section, and, before entering the chimney shaft, which is 60 ft. high, it passes through a condensing chamber provided with baffles to intercept any solid matter carried off by the flue gases.

### Furnace Management.

For the prevention of accidents in the use of the large volumes of gas and air delivered to the furnaces, a recognised system of workshop procedure was necessary. The following routine was found from the first to work satisfactorily. All the air valves are opened, and the blower is then started to deliver air to the furnaces. Then, dealing with each furnace successively, the air valve is closed, the gas valve opened, the gas ignited, and the air-valve reopened to its utmost capacity. So soon as the whole series of furnaces is alight, the gas and air taps are adjusted to produce the proper burning mixture in each case.

In shutting off a single furnace, the gas valve is first closed, and then the air. When dealing with the whole battery, the gas valves are closed on all the furnaces, the pressure blower stopped, and the quadrant taps turned off.

Should the blower stop unexpectedly through the breakage of a belt or from other causes, all gas and air taps are closed immediately to prevent the suction of gas into the air pipe when the pressure is removed and the formation of an explosive mixture. In view of this emergency the air pipes are, in some cases, provided with non-returnable valves, which are automatically brought into action as soon as the pressure ceases. Experiments are in progress to ascertain the simplest and most effective form of safety device for such a contingency.

The furnace linings receive close attention, which is repaid by a lengthened life. The surfaces are kept free from excrescences which would obstruct the free passage of the gas flame. Accumulations of slag at the bottom of the furnace are cleaned out at frequent intervals. Faults in the brickwork arising from the alternate heating and cooling, or from other causes, are patched immediately. In general result the entire lining of a furnace is renewed two or three times a year.

### Ventilation.

Provision is made for the ventilation of the melting-house by means of fans. Three Blackman fans, situated one at each end and one at the side, are installed near the roof. These can be used either for supply or exhaust, as required. If two of the fans are drawing from the room, and one is discharging into it, the whole volume of air is changed every five minutes, independently of the doors, windows, and skylight. It is possible, therefore, to keep the room clear of the fumes which arise, especially during pouring, and also to maintain the general temperature of the workshop at a reasonably low level. The latter becomes a particularly important consideration during the melting of bronze and cupro-nickel in the hot weather, and bears directly upon the efficiency of the workmen. But the flue accommodation itself is amply sufficient for the removal of any products of imperfect combustion, should these occur in the furnaces, and no inconvenience in this respect has at any time arisen in the melting-houses.

*(To be continued.)*

## STEAM RAISING BY WASTE GASES.

By A. Houlson.

The utilisation of the waste gases from forging furnaces for the purpose of evaporating water in steam boilers is steadily becoming more frequent, due no doubt to the general desire to effect the greatest possible economy in fuel.

The system carries with it certain disadvantages. For instance, the gases are not only composed of the usual constituents which are found in the flues of an ordinary grate-fired boiler, but contain also certain deleterious fumes arising from the heating of the metal, which sometimes cause a rapid deterioration of the boiler plates and rivets. The heat is intense and fluctuating. Several types of boilers are quoted as being suitable for this class of service, viz.: The vertical type, the locomotive type, and the water-tube type, the two former for evaporative capacities up to 3,600 lbs. water per hour, the latter for higher capacities. The temperature of the gases reaching the combustion chamber of the boiler varies from 1,500 deg. to 2,000 deg. Fah. It is not worth while to instal the system in the case where the gases are below 1,500 deg. Fah., neither is it customary to allow the gases to have a higher temperature than 2,000 deg. Fah. in the combustion chamber.

The distance between the furnace and the inlet to boiler should be as short as possible. It has been found that a drop in temperature of 10 deg. Fah. takes place for every foot length of flue between furnace and boiler. The flues should be as straight as possible, and slope up to boiler inlet, which is above level of furnace.

### The Main Difference.

The main difference between the conditions prevailing in the case of an ordinary boiler fired on the grate, and one heated solely by hot gases is that, in the latter case, the heat radiated from the incandescent fuel on the grate is

not available. In an ordinary loco-type boiler, grate fired, the rate of heat transference, including radiation, may reach 7 B.T.U.s per square foot heating surface per degree difference mean temperature of steam and hot gases per hour.

When, however, the boiler is heated solely by hot gases, and the radiation from the fuel is absent, the rate of heat transference for the range of temperatures given above, viz., 1,500 deg. to 2,000 deg. Fah., is 3 to 3·7 B.T.U s per square foot heating surface per degree difference mean temperature of steam and hot gases per hour. The evaporation depends upon volume of gas as well as upon its temperature.

If $W$ = weight of flue gases per pound of fuel burnt,
$k$ = specific heat of flue gases,
$T_1$ = temperature (absolute) of gases at inlet to boiler.
$T_2$ = temperature (absolute) of gases at outlet from boiler.

Then, heat lost by gases per pound of fuel burnt = $Wk(T_1 - T_2)$.

Also, if $H_s$ = heat supplied to water and steam in boiler from temperature ($t_2$) of feed to boiler, to steam at given pressure and temperature ($t_s$).

$w$ = weight of water evaporated per lb. of fuel burnt.

Then $wH_s = \cdot 9\,Wk\,(T_1 - T_2)$ allowing 10 per cent for losses. $T_s$ may be obtained when the other values are given.

**To take an actual case :**

Let $T_1$ = 1800 = 2260 deg. Fah. absolute ; $t_s$ = 338 = 798 deg. Fah. absolute. $W = 21$ ; $k = \cdot 24$ ; $t_2$ = 62 deg. Fah. ; Heating surface in boiler = 600 square feet ; weight of coal burnt per hour = 384 lbs. $H_s$ = 1154·5. Working pressure of steam in boiler 100 lbs. per square inch.

$$\cdot 9 \left\{ 394 \times 21 \times \cdot 24\,(2260 - T_2) \right\} =$$

$$3{\cdot}5 \times 600 \times \left\{ \left(\frac{2260 + T_2}{2}\right) - 698 \right\}$$

$\therefore\ T_2$ = 1160 = 700 deg. Fah.

$$w = \frac{\cdot 9 \times 21 \times \cdot 24 \times (2260 - 1160)}{1154{\cdot}5} = 4{\cdot}3$$

It is essential in these boilers to allow sufficient area through the flues or tubes, and in the chimney to ensure that the draught shall not be impaired. The height of the chimney should be at least 60 feet. With a smokebox temperature of 600 deg. Fah. this gives a draught of $^7/_{16}$ in. at chimney base, and $^3/_{16}$ in. at inlet to boiler.

The cross-sectional area is computed from the formula :—

$A = \dfrac{\cdot 117\,Q}{\sqrt{H}}$ where $A$ = area in square feet.
$Q$ = lbs. of coal burnt per hour.
$H$ = height of chimney in feet.

$Q$ = 200 minimum to 600 maximum in these boilers.

The area through the tubes is usually about 12 per cent less than A, as calculated above.

**Water-tube Boilers.**

Turning our attention to water-tube boilers, we find that the rate of heat transference of these boilers when utilising waste heat gases ranges from 3·5 to 4·5 B.T.U.'s per square foot heating surface per hour per degree mean temperature difference of steam and hot gases (as compared with 8·4 maximum when boiler is fired on the grate) ; and the evaporation of water per pound of coal from and at 212 deg. Fah. sometimes reaches the value $8\frac{1}{2}$.

Messrs. Babcock and Wilcox, in their book "Steam," page 195, give particulars of a trial on a large water-tube boiler of their make, in which the water was evaporated by waste gases from a heating furnace. An analysis of the trial works out as follows :—

$T_1$ = 2000 (assumed), *i.e.*, 2460 deg. absolute ; $t_s$ = 306 = 766 deg. Fah. absolute ; $W = 24{\cdot}5$ ; $k = \cdot 24$ ; $t_2$ = 48 deg. Fah. ; Heating surface in boiler = 1426 square feet ; Weight of coal burnt per hour = 626 lbs. ; $H_s$ = 1159 ; $T_2$ = 500, *i.e*, 960 deg, Fah. absolute.

$$w = \frac{\cdot 9 \times 24{\cdot}5 \times \cdot 24\,(2460 - 960)}{1159} = 6{\cdot}9$$

B.T.U.s transmitted per square foot of heating surface per degree difference of the mean temperatures of steam and hot gases per hour =

Weight of steam evaporated per square foot heating surface per hour × Total heat $H_s$ supplied to steam ÷

$$\frac{T_1 + T_2}{2} - t_s$$

$$= \frac{3 \times 1159}{1710 - 766} = 3{\cdot}7.$$

$$\text{Also}\quad \cdot 9 \left\{ 626 \times 24{\cdot}5 \times \cdot 24\,(2460 - 960) = 3{\cdot}7 \times 1426 \times \left\{ \left(\frac{2460 + 960}{2}\right) - 766 \right\} \right.$$

**Test on a Stirling Water-tube Boiler.**

Particulars of a test on a Stirling water-tube boiler heated by waste gases from coke ovens are given in the *Engineer*, September 2nd, 1904.

The heating surface was 1,611 square feet. The working steam pressure in boiler was 125 lbs. $T_1$ = 1700 = 2160 deg. Fah. absolute ; $t_s$ = 353 = 813 deg. Fah. absolute ; $T_2$ = 620 = 1080 deg. Fah. absolute ; B.T.U.s transmitted per square foot of heating surface per degree difference mean temperature steam and hot gases per hour

$$= \frac{3{\cdot}81 \times 966}{1620 - 813} = 4{\cdot}55.$$

$w$ = 1·61 from and at 212 deg. Fah., showing that the heat capacity of the gas from each pound of coal coked in the ovens is very low.

Substituting in the equation $wH_s = \cdot 9\,Wk\,(T_1 - T_2)$ we get

heat capacity of gas per lb. coal $= Wk = \dfrac{1{\cdot}61 \times 966}{\cdot 9(2160 - 1080}$

The heat capacity in the two previous examples = 5·05 and 5·88 respectively, *i.e.*, more than three times as great. This, however, is easily explained, when it is remembered that the heat extracted from the coal during the coking process is only $37\frac{1}{2}$ per cent of its calorific value, and, further, that of this $37\frac{1}{2}$ per cent half is lost in radiation from the ovens and flues. Also, the boiler inlet was 29 ft. from the oven which accounts for the comparatively low inlet temperature $T_1$.

**Gases from a Puddling Furnace.**

The gases from a puddling furnace were found to have a heat capacity of five to six approximately, as in the case of heating furnaces. The water evaporated per square foot of heating surface per hour = $2\frac{1}{4}$ lbs. from and at 212 deg. Fah. approximately, corresponding to a heat transference coefficient of $1\frac{3}{4}$ to 2 B.Th.U. per hour per degree difference of temperature per square foot of heating surface. The water evaporated per pound of coal fired on the grate of the puddling furnace = 8 lbs. from and at 212 deg. Fah. The final temperature of gases is about 600 deg. Fah., and the draught at chimney base = $\frac{1}{2}$ in.

## Waste Gases from a Blast Furnace.

When utilising the waste gases from a blast furnace the boiler is so constructed that the air for combustion is heated before meeting the gas. The water evaporated per square foot of heating surface per hour from and at 212 deg. Fah. may reach $5\frac{1}{4}$ lbs., which corresponds to a heat transference of $4\frac{3}{4}$ B.Th.U. per square foot per hour per degree difference of temperature. The final temperature of gases varies from 600 deg. to 750 deg. Fah.

## Waste Heat from Destructor Furnaces.

Another source from which steam may be economically raised is the waste heat from destructor furnaces. Owing

STEAM RAISING BY WASTE GASES.

VERTICAL AND LOCO-TYPE BOILERS.

| Source of Heat. | Evaporative Capacity Water per Hour from and at 212 Deg. Fah. Lbs. | | Consumption of Coal in Furnace per Hour. Lbs. | | Temperature of Gases Reaching Boiler Inlet. Deg. Fah. | | Temperature of Gases at Outlet from Boiler. Deg. Fah. | | Water Evaporated per Sq. Foot Heating Surface per Hour from and at 212 Deg. Fah. Lbs. | | Water Evaporated per Lb. of Coal Fired on Furnace from and at 212 Deg. Fah. Lbs. | | B.T.U.s Transmitted per Sq. Foot per Hour per Degree Difference of Temperature. Steam and Gas. | | Draught inches of Water Column. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | |
| Waste Gases from Forging or Heating Furnace. | 3600 | 740 | 600 | 200 | 2000 | 1500 | 730 | 710 | 3·9 | 2·4 | 6 | 3·7 | 3·7 | 3 | $\frac{7}{16}$ * |

* At Chimney.

WATER-TUBE BOILERS.

| Source of Heat. | Evaporative Capacity Water per Hour from and at 212 Deg. Fah. Lbs. | | Consumption of Fuel in Furnace per Hour. Lbs. | | Temperature of Gases Reaching Boiler Inlet. Deg. Fah. | | Temperature of Gases at Outlet from Boiler. Deg. Fah. | | Water Evaporated per Sq. Foot Heating Surface per Hour from and at 212 Deg. Fah. Lbs. | | Water Evaporated per Lb. of Fuel Fired on Furnace from and at 212 Deg. Fah. Lbs. | | B.T.U.s Transmitted per Sq. Foot per Hour per Degree Difference of Temperature. Steam and Gas. | | Draught inches of Water Column. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | Maxm. | Minm. | |
| Waste Gases from Forging or Heating Furnace. | 26000 | 3500 | 3100 | 600 | 2000 | 1500 | 500 | .. | 3·6 | .. | 8·3 | .. | 3·7 | .. | $\frac{1}{2}$ |
| Waste Gases from Puddling Furnace. | .. | .. | .. | .. | 2200 | .. | 600 | .. | 2·3 | .. | 8 | .. | 2 | .. | $\frac{1}{2}$ |
| Waste Gases from Blast Furnace | .. | .. | .. | .. | 2000 | .. | 730 | .. | 5·2 | .. | .. | .. | 4·7 | .. | .. |
| Waste Gases from Coke Ovens. | .. | .. | .. | .. | 1700 | .. | 620 | .. | 3·8 | .. | 1·6† | .. | 4·5 | .. | $\frac{9}{16}$ |
| Waste Gases from Refuse Destructor | .. | .. | .. | .. | 2032 | .. | 500 | .. | 4 | .. | 2·16 | .. | 4·4 | .. | 1 |

† Messrs. Babcock & Wilcox give maximum value as 2·2.

to the low calorific value of the fuel burnt in the cells of the destructor, the heat capacity of the gas is very small, seldom exceeding two; consequently, the evaporation of water per pound of refuse is very low. A reasonable average figure to take is $1\frac{3}{4}$ lbs. from and at 212 deg. Fah., although higher figures have been occasionally obtained. As high as 2·63 in one case. The water evaporated per square foot of heating surface per hour = four from and at 212 deg. Fah., corresponding to a heat transmission coefficient of $4\frac{1}{2}$ B.Th.U. per square foot per hour per degree difference of temperature. The final temperature of gases varies from 500 deg. to 700 deg. Fah. Two interesting papers on refuse destructors, embodying several tests on boilers fired by waste gases therefrom will be found in the Proceedings of the Institute of Mechanical Engineers, June, 1904.

It may be noted that an air blast of 1 in. is used in these destructor furnaces, and an intense heat is generated in the cells, rising at times to 2,300 deg. Fah. As mentioned above, this heat fluctuates from time to time. The boiler, therefore, should be designed to withstand the stresses due to frequent contraction and expansion. Thin tubes and rapid circulation of water are preferable to thick plates and sluggish circulation. Provision should be made for readily removing the dust deposited on the tubes or other portions of the heating surfaces, as these gases carry a large amount of dust, a feature they have in common with the gases from a blast furnace.

A table giving a brief summary of the foregoing results is appended.

## COAL GAS AS A FUEL FOR MELTING NON-FERROUS ALLOYS.

By George Bernard Brook.

(Lecturer in Non-ferrous Metallurgy in the University of Sheffield.)

*(Continued from page 295.)*

### Description of Gas Furnace Used.

The furnace consisted of a self-contained unit, pit-fired pattern, taking a 60-lb. crucible. The body was of cast iron, and the heating chamber insulated. The lining of the furnace consisted of specially-prepared refractory bricks.

The furnace was fitted with a double-hinged bottom door actuated by a lever to facilitate removal of metal in case of accidental spilling or breakage of crucible. The cover was mounted as shown on four wheels, so as to enable the crucible to be easily withdrawn for pouring. The burners were duplex, controlled by dial taps. The air under pressure was supplied from a belt-driven positive blower at a pressure of 3 in. to 6 in. of mercury. Special claim was made for the type of burner in that efficient mixing of gas and air was secured.

Reference to Fig. 1a will show all details of the furnace.

*The Object of the Test.*—The main points which the writer had in view were as follows:—

1. Would ordinary (coal) gas give a temperature that was sufficiently high for the successful casting of cupro-nickel?

2. What was the relation between the coke-fired furnace and gas-fired furnace from the following standpoints?:—

 (*a*) Cost of melting.
 (*b*) Speed of melting.
 (*c*) Life of crucibles.
 (*d*) Wear and tear of lining and burner.
 (*e*) Melting losses.
 (*f*) Labour charges.
 (*g*) Capital charges.
 (*h*) Quality of metal produced.

And generally the relative mechanical advantages and disadvantages of the two systems.

(1) *Temperature Attained.*—As is probably well known to members, the temperature at which cupro-nickel must be cast is a critical one and lies within comparatively narrow limits. No difficulty, however, was found in attaining the desired temperature, as a maximum heat of 1,400 deg. Cen. was readily obtained.

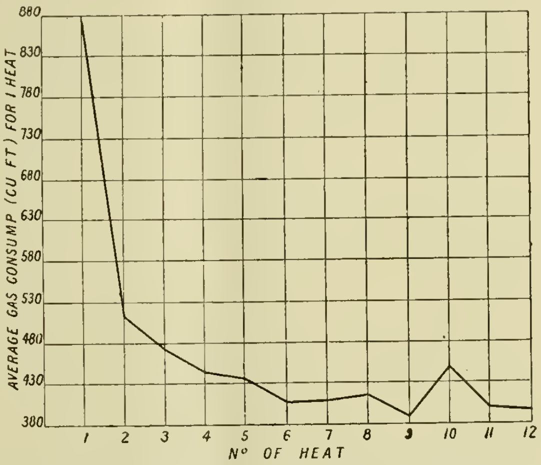



Fig. 2.—Average Gas Consumption per Heat for corresponding Heats. The graph is very similar to the time diagram 3, and shows a minimum consumption of 880 c. ft. for the first round (starting at cold) with a drop to 510 ft. for the second round, and gradual fall to the minimum of 390 between the ninth and twelfth rounds.

The pyrometer used was one designed specially for determining the temperature of molten metal in crucible furnaces. The determination of such temperatures has always been a matter of great difficulty.

The essentials of the pyrometer used were as follows:—A fused silica tube, 6 ft. long and $1\frac{1}{2}$ in. diameter, was attached to an iron headpiece containing a convex mirror and thermo-couple, and was connected, as usual, through a millivolt-meter. The silica tube was passed through an asbestos cover, which replaces the ordinary one on a fur-

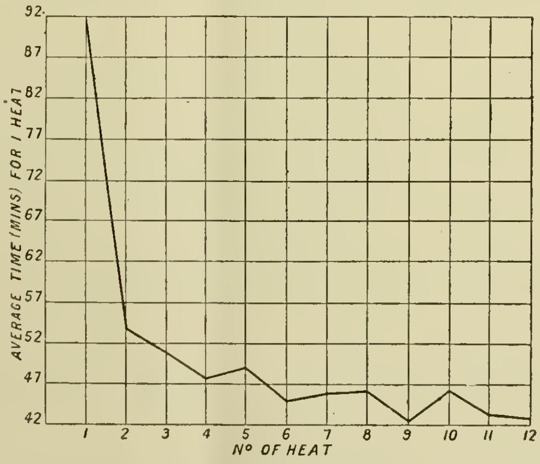



Fig. 3.—Average Time per Heat for corresponding Heats, showing on the whole a uniform fall with each succeeding heat (starting from cold). The average time of the first round was 91 minutes, with a rapid fall of the second to $53\frac{1}{2}$, and a decrease down to 42 minutes between the ninth and twelfth rounds.

nace, and carefully heated and pushed down into the molten metal until it was about one-third of the way from the bottom of the crucible. About three minutes was required to attain the maximum steady reading on the instrument.

The life of the silica tube may with care be prolonged to a maximum of thirty immersions, but in some cases very few readings were obtained before the tube failed. Despite this unavoidable expense, in most cases the valuable data obtained compensated the additional cost.

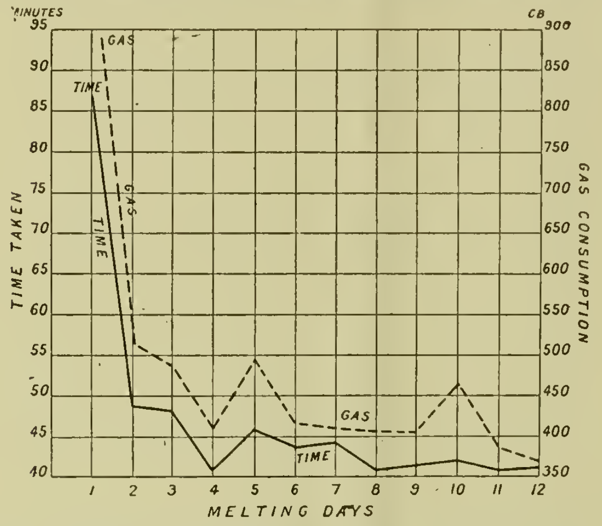



FIG. 4.—Average Gas Consumption and Times. 6th to 10th days.

(2*a*) *Cost of Gas Compared with Coke.*—The total gas consumption for the entire run was 46,125 cubic feet. At the current price of gas in Sheffield, 1s. 9d. per thousand cubic feet, this would cost £4 0s. 6d.

If, however, it were possible to secure gas at the rate allowed to users of gas engines, viz., 1s. 4d., the above figure would be reduced to £3 1s. 6d.

These figures represent respectively 31s. 9d. and 24s. 2d. per ton of metal melted. The average cost of melting over 400 tons of the same alloy in coke-fired furnaces was 36s. 4d. per ton.

(2*b*) *Speed of Melting.*—In Table II. and Figs. 2 and 3 is shown in detail the average time per heat and gas consumption for each day. The results are intensely interesting, and show that the time required to bring

TABLE II.—TOTALS AND AVERAGES.

| Day. | Heats. | Total Time (mins.). | Average Time per Heat. | Average Consumption of Gas. |
|---|---|---|---|---|
| 1 | 6 | 372 | 62·0 | 508 |
| 2 | 9 | 547 | 60·8 | 521 |
| 3 | 9 | 551 | 61·2 | 477 |
| 4 | 12 | 554 | 46·2 | 443 |
| 5 | 8 | 445 | 55·6 | 498 |
| 6 | 9 | 480 | 53·3 | 511 |
| 7 | 11 | 536 | 48·7 | 470 |
| 8 | 10 | 506 | 50·6 | 527 |
| 9 | 10 | 457 | 45·7 | 458 |
| 10 | 12 | 527 | 44·0 | 431 |
| Average for 10 days of 96 heats ...... | | 497·5 | 51·8 | 480·5 |

cupro-nickel to the necessary temperature for casting is much less than in the coke-fired natural-draught furnace. Taking the average of the whole of the heats (that is, including the first three heats during which experience was being gained), the averages would be as follows:—

Average time of 56-lb. heat in gas furnace ... 52 minutes.
" " " coke furnace .. 82 "

In an ordinary working day of ten hours it is rarely possible to get more than five heats out a coke-fired furnace, but it will be noticed that on two days during the gas-melting test, twelve heats were secured in less than ten hours. Time is admittedly one of the most important economic factors in the melting of metals, and the above results show a very considerable advantage in the use of gas.

As the test proceeded, the gas consumption and time required for each melt improved. The results in detail and average are shown for the sixth and succeeding days in Tables III. and IV., and plotted in graphical form in Fig. 4.

***(To be continued.)***

TABLE III.—GAS CONSUMPTION.

| Day. | Round 1. | Round 2. | Round 3. | Round 4. | Round 5. | Round 6. | Round 7. | Round 8. | Round 9. | Round 10. | Round 11. | Round 12. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 1047 | 471 | 424 | 369 | 521 | 427 | 461 | 469 | 410 | .. | .. | .. |
| 7 | 762 | 509 | 502 | 417 | 425 | 435 | 449 | 408 | 434 | 435 | 396 | .. |
| 8 | 945 | 595 | 586 | 465 | 475 | 462 | 414 | 419 | 428 | 478 | .. | .. |
| 9 | 784 | 529 | 466 | 402 | 445 | 399 | 388 | 367 | 376 | 422 | .. | .. |
| 10 | 760 | 456 | 435 | 381 | 352 | 400 | 373 | 381 | 396 | 506 | 366 | 369 |
| Total ........ | 4298 | 2560 | 2413 | 2054 | 2220 | 2123 | 2078 | 2044 | 2044 | 1841 | 762 | .. |
| Average ...... | 859·3 | 512·0 | 482·3 | 410·4 | 444·0 | 424·3 | 413·3 | 408·4 | 408·4 | 460·1 | 381·0 | .. |

TABLE IV.—TIME TAKEN.

| Day. | Round 1. | Round 2. | Round 3. | Round 4. | Round 5. | Round 6. | Round 7. | Round 8. | Round 9. | Round 10. | Round 11. | Round 12. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 113 | 45 | 40 | 40 | 60 | 44 | 54 | 43 | 40 | .. | .. | .. |
| 7 | 78 | 54 | 50 | 42 | 45 | 45 | 48 | 43 | 42 | 47 | 43 | .. |
| 8 | 88 | 52 | 54 | 44 | 44 | 50 | 41 | 42 | 45 | 45 | .. | .. |
| 9 | 73 | 51 | 50 | 40 | 45 | 41 | 40 | 35 | 40 | 42 | .. | .. |
| 10 | 73 | 45 | 44 | 40 | 35 | 40 | 38 | 41 | 40 | 50 | 39 | 42 |
| Total ........ | 435 | 247 | 238 | 206 | 229 | 220 | 221 | 204 | 207 | 165 | 82 | 42 |
| Average ...... | 37·0 | 49·4 | 47·6 | 41·2 | 45·8 | 44·0 | 44·2 | 40·8 | 41·4 | 41·2 | 41·0 | .. |

## THE I.A.E. AND THE S.A.E.

The existing bonds of friendship between the British Institution of Automobile Engineers and the American Society of Automotive Engineers, which have been so close since the visit of the latter to this country in 1911, and the visit of the former to the U.S.A. in 1913, have now been further cemented by the entry of America into the war, as is evidenced by the following cablegram just received in London:—

"The Society of Automotive Engineers, formerly Society of Automobile Engineers, extends its congratulations to the Institution of Automobile Engineers on its able service in assisting its Government in motor transportation and kindred activities. We consider the farm tractor one of the most potential elements in solving the food problem. Our membership includes tractor engineers of all leading manufacturers; much tractor experience and information is at our command, and in extending our brotherly sympathy and co-operation in the common struggle for democracy, we formally place all our data at your disposal and would be honoured to collaborate in any way you desire. Standardisation in farm tractor manufacture, as well as in airplane and motor boat manufacture, is being pushed vigorously and other activities are being forwarded aggressively. Command our assistance as you desire in the food increase work.

"Society of Automotive Engineers."

The value of such an offer just now cannot be over-estimated, and the cable was immediately laid before the Government Department concerned and most cordially received. The reply of the I.A.E., while heartily reciprocating the brotherly feelings expressed in the cable, embodied a statement of the best method in which the magnificent services offered could be turned to the best account. Thus do friendships contracted without any very definite object in view during peace times, bear fruit a hundredfold in times of crisis. It is, further, a full justification of the decision of the Council of the I.A.E. to keep on in full swing, and is not the only direction in which it has recently been of assistance to the country.

## TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.

A new committee, to be known as the Technical Committee of the Motor Industries, has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders in order to co-ordinate the many technical questions which arise in connection with the automobile industry and which have been handled independently in the past. For instance, the Institution of Automobile Engineers formed a Steel Committee over two years ago that did a lot of useful work for the purpose of standardising steels for use on automobiles, and they are also represented on many of the automobile sub-committees of the Engineering Standards Committee; the Society of Motor Manufacturers and Traders have at the same time been represented on those sub-committees, while various other technical matters have been dealt with by their Standardisation, Technical and Research Committee which has existed for some time.

Matters have now been put on a better footing, and a joint permanent committee has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders which will be known by the above title. It is hoped that by this pooling of interests that not only will all overlapping be prevented in future, that the committee, strengthened as it will be by the addition of representatives nominated by the various Government Departments and institutions, will be recognised by the Council of Scientific and Industrial Research and all concerned as the proper body to treat with in all technical matters connected with the motor industry.

Invitations to be represented on the committee have already been accepted by the following: National Physical Laboratory, represented by Dr. Stanton; General Post Office, Capt. Wheeler; Institution of Mechanical Engineers, Dr. Hele-Shaw; Iron and Steel Institute, Mr. J. H. Dickenson; Commercial Motor Users' Association, Mr. Geo. Watson.

The Technical Committee will take over the work hitherto carried on by the Standardisation, Technical and Research Committee of the Society of Motor Manufacturers and Traders, the Steels Committee and the Standardisation Committee of the Institution, and the Research Committee which is carrying out research on the E.S.C. British standard steels for automobiles with the addition of aircraft steels, and which is financed by a Government grant of £1,000 and a donation of £1,000 from the Society of Motor Manufacturers and Traders and the trade generally. The work in the various directions will be carried out either by the existing committees or by specially appointed sub-committees of representative character who will report to the main committees, which in turn will deal with the Government Department concerned, or with the Engineering Standards Committee. It is hoped that by means of this organisation the voice of the industry will be heard in all the technical problems that are bound to arise after the war.

Further information can be obtained from either of the joint secretaries, Mr. Basil H. Joy, secretary, the Institution of Automobile Engineers, 28, Victoria Street, London (S.W.1.), or Mr. T. F. Woodfine, secretary, the Society of Motor Manufacturers and Traders, 83, Pall Mall, S.W., 1.

## SUPERHEATED STEAM.

By A. Vincent Clarke.

The advantages of superheated steam are now well known, but it often becomes necessary for an engineer-in-charge to make a study of this subject preparatory to making recommendations for the adoption of a superheater in order to reduce his coal bill or to avoid extensions to boiler plant, etc. Certain fundamental conditions are common to all plants, but there are new problems arising in nearly every case which must be studied and decided by the light of experience.

The difference between superheated and ordinary or saturated steam is that the latter is steam generated in proximity of the water in the boiler, and it is in such a condition that under the same pressure no heat can be extracted from it without causing condensation. When the steam is heated beyond this temperature it is said to be superheated, and this superheated steam can be reduced to its saturation temperature without liquifying. Thus the temperature of saturated steam at a pressure of 150 lbs. per square inch is 365 deg. Fah., and when this steam is increased to 500 deg. Fah. without its pressure being increased it is said to have 135 deg. of superheat.

Superheaters should transmit the highest number of heat units per square foot of heating surface per hour for every one degree of temperature difference between the flue gases outside and the steam inside the pipes. They are of two general types, direct connected and independently fired, the former being heated by the flue gases of the boiler to which it is attached. Independently-fired superheaters are usually placed in a brickwork setting entirely separated from the boiler setting and heated by a fire on its own grate. The same overall economy cannot be expected from these as from the direct connected type, as the lesser amount of steam used is to some extent counterbalanced by the extra fuel required to heat the steam. The hot gases from the combustion chamber of these superheaters impinge on the exterior of the tubes conveying the steam and are suitably baffled and deflected so that the maximum quantity of heat can be taken away by the steam. Also, the steam which flows through the superheater tubes or coils has to pass through successive rows in order to absorb as much heat as possible. Direct-connected superheaters are generally connected to the outlet for the saturated steam, which they conduct through tubes or coils, these coils being in contact with the hot gases, or, in other words, constituting a part of the boiler. The addition of a superheater to a boiler means adding to the heating surface; this surface differs from the ordinary heating surface only in that the steam passing through the superheater tubes is not in contact with the water in the boiler. There is no uniform practice as to the location of the superheater, for it depends to a large extent on the design of the boiler. The most common position in a horizontal water-tube boiler is between the tubes and the drum or drums. Sometimes the spacing of the tubes is changed so as to leave room for the superheater among them.

Some superheaters are placed in a chamber formed in the side walls of the boiler setting, part of the boiler gases being bye-passed through this chamber. In boilers of the horizontal-return tubular and internally-fired type the superheater is generally placed in the rear combustion chamber. The best location is open to question, but it is common to place it as far forward in a boiler as is possible without burning it. This gives a minimum amount of surface in the superheater per degree of superheat desired. Superheaters are sometimes placed in the uptake or the flue leading to the stack. The advantage of this location as compared with one farther forward is that the gases have done all their work in the boiler, and the heat taken from them is all gain. Another consideration is that it requires superheater in the uptake can be made to take care of a a minimum change to boilers already installed, as one number of boilers. The principal objection to a superheater in the uptake is that it is possible to get only a low degree of superheat, as the gases in the uptake are rarely over 600 deg. Fah. Also, the weight of a superheater per horse power per degree of superheat obtained is greater than in any other location, owing to the small temperature difference between the steam and the surrounding gases. This will in most cases make the cost of a superheater prohibitive. Superheaters can be adapted to almost any type of boiler in service with comparatively little change to the boiler or piping.

Loss of heat from the steam pipes between the boilers and the engine is unavoidable even if the pipes are well lagged; therefore a certain amount of saturated steam would condense in them, and the condensation will be in proportion to the moisture contained in the steam. The condensed steam not only does no work, but acts as a hindrance in the engine cylinder. Also, an appreciable saving in a plant will be realised in the pipe lines when passing superheated instead of saturated steam, because the former has a much lower thermal conductivity than the latter. A higher steam velocity can be used in the pipes with superheated steam without increasing the drop in pressure. This will allow a saving in the cost of piping and decrease the loss due to radiation. In an old installation it is seldom desirable to alter the existing piping when installing superheaters; therefore the saving due to smaller pipes cannot be considered. A point which must be carefully looked into when changing over a plant from saturated to superheated steam is whether the existing pipe fittings and valves are suitable for the lighter temperature steam. A great amount has been written regarding the materials and fittings suitable for superheated steam, and it appears to be generally conceded that all pipes and fittings should be of steel.

The increased economy due to the use of superheated steam in a 250 H.P. plant having a boiler pressure of 155 lbs. and a single-cylinder non-condensing engine fitted with a piston slide valve is given in Table 1; the percentage gains are given for both the engine and boiler, and the advantage of the various degrees of superheat is quite apparent. It will be observed that the higher amount of superheat did not produce a corresponding reduction in the steam and fuel consumptions.

Table 2 shows the effect of various degrees of superheat on the amount of steam and coal used by a plant having a boiler working at 130 lbs. pressure and a 250 I.H.P. compound condensing engine fitted with drop valves. It will be seen that the percentage saving on the engine does not necessarily give the saving on the whole plant, as the benefit on the auxiliary plant such as feed pumps, etc., is doubly obtained on account of their more economical working with the superheated steam and the smaller amount of work they have to do because of the reduced demand for steam.

In the third table the results from a much larger plant are given, and this was commenced with a very economical high-class triple-expansion engine working at 185 lbs. pressure, so the same percentage increase in economy should not be expected from the installation of a superheater. The figures show that the greatest economy is obtained with the use of highly superheated steam; to use this, however, it is essential that the engine should be of a suitable design.

The "Corliss" valve, which has given satisfactory results in saturated steam practice, cannot be applied for a steam of very high temperature on account of its large wearing surface, which is difficult to lubricate, and which expands by reason of the high heat of the steam so much that it has given serious trouble by sticking. It is generally conceded that a superheat of from 100 deg. to 120 deg. Fah., with a final temperature of the steam of not more than 475 deg. Fah. at the valve, is allowable for this type of valve. This is not high enough, especially in high-duty engines, to obtain maximum economy; therefore with the use of highly superheated steam it is necessary to adopt the double-seated poppet valve for high-pressure cylinders if not for all of them.

If valve casings are cast on the cylinders of engines using highly superheated steam, they should be of as simple a form as possible, and no steam passages should be cast on the barrel; it should take the form of a straight pipe, and it is advantageous to locate the valves in the cylinder heads in order to secure this result. Three rings are usually fitted to the pistons of large engines, and for horizontal engines the piston should be guided outside of the cylinder by the cross head and an extra liberal bearing for the

extended piston rod, so that the piston body will not ride on the cylinder wall. The piston should be lubricated directly and not by mixing the oil with the admission steam.

Many other test results are available for showing the benefits arising from the use of superheated steam, but the foregoing were chosen because of their completeness. If the superheating of the steam is sufficient, an initial condensation in the engine cylinders is entirely prevented. According to Mr. Michael Longridge to secure full advantage the superheater should be heated with gases from 1,000 deg. to 1,200 deg. Fah. in temperature, and that if the difference between the temperature of the gases outside and the steam inside the superheater is 450 deg. to 550 deg. the quantity of heat transmitted per hour is about 6 B.Th.U. per square foot of surface for each degree difference of temperature, but if the difference or head of temperature falls to about 150 deg. to 200 deg., the rate of transmission falls to about 1 B.Th.U. per square foot per hour. Therefore, the waste gases from a boiler should possess a temperature of considerably more than 200 deg. Fah. above that of the steam in the boiler, otherwise they are of little use for superheating purposes.

TABLE 1.

| Degree of Superheat. | Temperature of Steam. | I.H.P. | Cut off per cent. | At Engine. | | | At Boiler. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Steam per I.H.P. Hour. | Saving over Sat. Steam. | | Feedwater per I.H.P. Hour. | Saving over Sat. Steam. | |
| | | | | | Steam per cent. | Fuel per cent. | | Feedwater per cent. | Fuel per cent. |
| 0 | 369 | 250 | 20·00 | 27·0 | .. | .. | 29·00 | .. | .. |
| 103 | 472 | 250 | 20·88 | 21·05 | 22·0 | 18·5 | 21·47 | 26·0 | 22·5 |
| 162 | 531 | 250 | 21·35 | 20·00 | 25·5 | 20·0 | 20·40 | 29·5 | 24·0 |
| 234 | 603 | 250 | 21·75 | 18·75 | 30·5 | 22·0 | 19·13 | 34·0 | 26·0 |

TABLE 2.

| Degree of Superheat. | Temperature of Steam. | I.H.P. | Cut off per cent. | At Engine. | | | At Boiler. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Steam per I.H.P. Hour. | Saving over Sat Steam. | | Feedwater per I.H.P. Hour. | Saving over Sat. Steam. | |
| | | | | | Steam per cent. | Fuel per cent. | | Feedwater per cent. | Fuel per cent. |
| 0 | 354 | 250 | 6·00 | 14·72 | .. | .. | 15·73 | .. | .. |
| 130 | 484 | 250 | 6·95 | 12·50 | 15·0 | 11·5 | 12·70 | 20·0 | 16·0 |
| 202 | 556 | 250 | 7·50 | 11·75 | 20·0 | 14·0 | 11·98 | 24·5 | 18·5 |
| 274 | 628 | 250 | 8·00 | 10·85 | 26·0 | 17·5 | 11·09 | 30·0 | 21·5 |
| 338 | 692 | 250 | 8·50 | 10·51 | 28·5 | 18·5 | 10·75 | 32·0 | 22·5 |

TABLE 3.

| Degree of Superheat. | Temperature of Steam. | I.H.P. | Cut off per cent. | At Engine. | | | At Boiler. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Steam per I.H.P. Hour. | Saving over Sat. Steam. | | Feedwater per I.H.P. Hour. | Saving over Sat. Steam. | |
| | | | | | Steam per cent. | Fuel per cent. | | Feedwater per cent. | Fuel per cent. |
| 0 | 381 | 5,000 | 4·00 | 11·82 | .. | .. | 12·70 | .. | .. |
| 144 | 525 | 5,000 | 4·85 | 10·90 | 7 | 3·0 | 11·25 | 11·5 | 7·5 |
| 216 | 597 | 5,000 | 5·15 | 10·32 | 13 | 6·0 | 10·52 | 17·5 | 11·0 |
| 288 | 669 | 5,000 | 5·40 | 9·60 | 19 | 9·0 | 9·80 | 23·0 | 14·0 |
| 353 | 734 | 5,000 | 5·85 | 9·20 | 22 | 11·5 | 9·40 | 26·0 | 16·5 |

## THE ENGINEERS' STRIKE

(*Continued from page 301*).

organised bodies of men representing the Government, the employers, and the men whilst the work of munition-making is going on. If, however, the men keep on playing the fool's game of acting without their executives then nothing but industrial chaos will reign, we shall run the serious danger of losing the war and entering upon a domination by Huns in this country, beside which the worst of our conditions here would be as bright as the brightest heaven that has ever been painted against the manufactured hell of a nation which has committed every loathsome crime known to history whenever opportunity has occurred.

## LOW-POWER STEAM TURBINES.

By J. HUMPHREY.

### Turbines v. Steam Engines.

Though it is undoubtedly true that from the point of view of economy steam turbines are most satisfactory when built for large outputs, a good many small turbines with capacities ranging from about 10 H.P. to 50 H.P. are now in operation. These turbines drive centrifugal pumps, ventilating fans, induced-draught fans, and other machines of a kindred nature, and they perform their work remarkably well. The only drawback to a small turbine is that the steam consumption is rather high, but the consumption is often made to appear worse than it really is by comparing it with the steam consumed by a reciprocating engine per indicated horse power. Clearly this is an unfair comparison, because when speaking of the power of a turbine, the shaft horse power is meant, for a turbine cannot be indicated. There is another point and a very important one. When an engine leaves the makers' works the valves are in good condition and are perfectly set, and the piston rings are quite steam tight, but as soon as the engine is set to work these parts begin to wear, and it is well within the range of possibility that after a time the steam consumption may, as the result of leaky valves and pistons, be considerably in excess of what it was at the outset. A turbine, on the other hand, having no slide valves or pistons to wear, is much less liable to increase its consumption, so that although a small reciprocating engine may show up to the best advantage when it is first set to work, there may not be much to choose between the two in the long run. Furthermore, a turbine is more simple than a reciprocating engine, and it is unnecessary to lubricate it internally. The exhaust steam is therefore perfectly clean, and it may be used for heating and other purposes without difficulty. Small turbines can be erected in places where ordinary electric motors would quickly come to grief, for damp and wet atmospheres are apt to ruin electrical insulation. Even totally-enclosed motors, which are necessarily more expensive than ordinary electric motors, are not so well suited for such conditions as steam turbines. Once a small turbine has been installed, it requires very little attention; in fact, with an automatic oiling system for the bearings, such as the oil ring system, turbines will run for indefinite periods without any attention at all. Turbines can therefore be erected in places where they are apt to be neglected. Whilst many figures have been published relative to the consumption of large and medium-sized turbines, few figures are available relative to small turbines. A test made on a modern 120-H.P. machine, however, which, of course, is a small output for a turbine, showed that the steam consumption was 17·85 lbs. per brake horse-power hour. The speed was 2,980 revolutions per minute, the vacuum 28 in., and the superheat 100 deg. Fah. A test on a smaller turbine, developing only a little over 40 H.P. showed that the steam consumption per brake horse power was 33 lbs. Of course, very high efficiency is not nearly so important with a small turbine of only a few horse power as it is with a large machine, although if a number of small turbines are used on a power plant the effect on the total steam consumption may not be exactly good. When electric current is available it may in many cases be more expedient to instal electric motors, but in the absence of such a supply a steam turbine is a good substitute.

### Turbines in Power Stations.

In modern power stations steam turbines are frequently installed for driving high-pressure centrifugal feed pumps and for driving the circulating pumps of condensers. For work of this kind turbines are well suited, for they are very robust and may be handled with perfect safety by unskilled men. Small turbine lighting sets for searchlights and the headlights of locomotives are also used fairly extensively in America. A fair number of firms in this country were building small turbines before the war, and there is no doubt that they will continue to do so when normal conditions are restored. The oldest form of small steam turbine is the De Laval machine, which is made in this country by Greenwood and Batley. Small reaction turbines, working on the Parsons principle, are built, but they are not so easily constructed as impulse turbines. Sir Charles Parsons' turbine, now in the British Museum, is, of course, a reaction turbine, and it works on exactly the same principle as all other turbines of the same type, but practically all the manufacturers who have taken up the manufacture of small turbines within the last few years have adopted the impulse principle, although the speeds are, as a rule, considerably lower than that of the De Laval machine, which in the smallest sizes runs at 30,000 revolutions per minutes. For all ordinary purposes this speed is, of course, much too high, and reduction gear has to be adopted. Steam supplied to the turbine passes through nozzles wherein it acquires a high velocity. In condensing turbines, the velocity is between 3,000 ft. and 4,000 ft. per second. On leaving the nozzles, the steam impinges on the blades of the turbine wheel, and by reason of the kinetic energy of the steam jets the rotor is caused to revolve. The ratio of the speed reduction provided by the gearing varies from 10 to 1 in the smaller sets to 13 to 1 in the larger sets which run at speeds as low as 9,500 revolutions per minute. The nozzles in which the steam is expanded are as in most other impulse turbines opened and closed according to the load, for it is well known that excessive throttling of the steam is not conducive to economy, and by closing some of the nozzles as the load decreases the best results are secured. From time to time the De Laval turbine has been modified and improved, and although many other small turbines are now built it is still employed extensively.

### Turbines with Compound Velocity Wheels.

Many small steam turbines now built have a compounded velocity wheel; that is to say, after the steam from the nozzle has struck the rotor blades, it passes into guide blades fixed into the interior of the turbine casing, and these guide blades direct the steam into a second set of blades mounted on the rotor. Turbines of this kind

are built by the British Westinghouse Co., the Oerlikon Co., and by Brotherhood Ltd., of Peterborough. The effect of providing a double set of blades on the rotor is, of course, that half the kinetic energy of the steam is expended in one row of moving blades and the other half in the other row, and the speed of the rotor is therefore lower than is the case when all the kinetic energy in the steam is expended in a single row of blades. The path of the steam in a turbine constructed on these lines is, as in the case of a De Laval turbine, wholly in a plane parallel with the axis of the turbine. Small steam turbines are also built with three rows of blades on the rotor when, of course, there are two rows of fixed blades attached to the interior of the rotor casing. The simple compounded rotor, however, with two rows of blades is usually adopted for ordinary steam pressures. Some small steam turbines have the nozzles arranged around the periphery of the rotor instead of on one side of it, and reversing buckets are cast together with the nozzles. The steam from the latter strikes the blades on the rotor in a direction at right angles to the axis of the machine, and, having done so, it reverses its direction and returns into the buckets, where it is again reversed and is directed once more on to the moving blades. Before the steam leaves the turbine through the exhaust pipe it has to enter and leave the rotor buckets several times, and when this has occurred the kinetic energy in the steam has been absorbed. This practice of passing the steam through the same rotor buckets a number of times and only imparting a portion of the kinetic energy in the steam, on each occasion has the same effect as passing the steam through several rows of separate blades; that is to say, the economical running speed is reduced to a value considerably below that of a De Laval turbine. When these turbines have to work at the higher steam pressures, two rotors are sometimes used, each having separate nozzles and return boxes, and after the steam has passed through the first stage, it enters the second through the second set of nozzles and return boxes arranged in a similar manner to those around the first wheel.

## SCALE "LOCATORS."

That carbonates of lime, etc., contained in water are deposited in the form of a hard scale when the water is boiled is well known; this scale is the cause of considerable expense and necessitates removal from steam and hot-water boilers and tanks, otherwise heat is wasted.

"Locators" is the name given to specially-designed and constructed sets of plates introduced by the Lawrence Patent Water Softener and Sterilizer Co. and used successfully for many years in their several types of water-heating, softening and sterilizing plants and apparatuses.

These plates are designed and constructed in different forms and sizes to suit the conditions and requirements, and can be used also in certain types of steam and hot-water boilers, as well as in hot-water tanks.

They have been proved to effectually collect scale which otherwise adheres to the interior surfaces of boilers and tanks with consequences too frequently realised.

"Locators" can be removed for cleaning, which is easily effected by tapping the hard scale with a light hammer, and by having a spare set the boiler or tank need not be kept out of use.

"Locators" have the effect of so baffling and distributing the water, as to prolong the course of travel or local circulatory motion which occurs when water is heated, and they bring a greater surface in contact with the water.

Further information can be obtained by writing to the Lawrence Patent Water Softener and Sterilizer Co. Ltd., Parliament Mansions, Victoria Street, London, S.W., and if particulars of the size and type of hot-water boiler or tank is sent a suggestion will be made to reduce the scale trouble.

## ELECTRIC SUPPLY TO COLLIERIES.*

By G. S. Corlett, M.I.E.E.

Broadly speaking, all colliery electric supply may be classified as either—Generated: That is, produced on the colliery premises for the purposes of the colliery or group of collieries; or Purchased: That is, furnished from an outside source of supply. The objects of such supply are very simple: (1) To perform one or more of the operations incidental to coal-getting. (2) To be available continuously or for such shorter periods as may be required. (3) To be reliable, so that there may be no interruption to the continuity of any desired operation, and this to be possible without undue attention on the part of the management. (4) To be flexible; that is, so that permanent or temporarily increased loads, or reduced loads for periods, can be economically dealt with. (5) To be cheap; *e.g.*, the total annual cost including capital charges should be the lowest possible figure.

It is, in the writer's opinion, quite impossible to make any general statement that it is usually desirable or undesirable to provide the supply by purchase or generation. The conditions differ to such a wide extent that any attempt to dogmatise would be futile. In order to arrive at a sound conclusion it is necessary to review various considerations, the more important of which are:

### (1) Choice.

Although there is a supply of electricity in most coalfields there are still many collieries outside the practical range of such supply. Should current be available, it is further necessary to see: (*a*) That it furnishes the kind of current required. Frequently supply is considered when an existing generating plant is either too small or of unsatisfactory type. In such cases the new supply should be suitable for the motors already installed. While the conversions from A.C. to D.C. and from one periodicity are simple engineering problems, they involve considerable capital outlay, and increased running costs owing to the losses incidental to the conversion. (*b*) That it is continuously available, reliable, and flexible. Should there be no such supply, a local generating plant must be provided, and the further points mentioned may be ignored except so far as they affect the design of the plant.

### (2) Finance.

(*a*) The cost of a suitable generating station with sufficient stand-by plant should be ascertained. (*b*) The cost of generated and purchased current should be compared, not only in the earlier stages of the installation, but over a period of at least five years. To make this comparison in a manner likely to be of real value, a considerable amount of trouble is necessary. (*c*) In those cases, by no means infrequent, where the amount of available capital is strictly limited, it is worth while considering

* Paper read before the Manchester Geological and Mining Society, April 17th, 1917.

whether the money could be more profitably used for other improvements than in the purchase of a generating plant.

### (3) Engineering.

(*a*) Load.—It is relatively easy to design a suitable generating station when the final requirements are definitely known, but the greater the doubt as to future needs, the greater the difficulty of design. While it is impossible to forecast colliery requirements accurately, it is always desirable to consider the question of load, to estimate carefully the rate of increase, and how the load will be distributed over the 24 hours. Further, the probabilities of major extensions should be considered, such as the opening out of additional seams, whether water now standing in disused workings, or otherwise being dealt with, may not later be pumped at the particular pit. (*b*) Fuel.—Under this head may be grouped such questions as: The quality of fuel available, its cash and calorific value, whether it can readily be sold in normal times or not? Is the existing boiler plant of sufficient capacity, and at a high enough pressure to furnish the required load economically, or do the conditions justify new high-pressure boilers? Is there a supply of heat energy such as exhaust steam, or waste heat from coke ovens, or elsewhere, which can be used at times when the load is required? (*c*) Life of Collieries.—It is usually desirable to estimate the probable life of the colliery, and so ascertain whether capital outlay on a generating station is economically sound. Doubtful conditions affecting or likely to affect the working period should be weighed up, such as possible water troubles, faults, or variation in the quality or demand for the coal.

### General.

In addition to the points already enumerated, and to which it is suggested a cash value can be allocated or approximated, there is another consideration which the writer is unable to express in £ s. d. For want of a better term this may be called the "Convenience Factor," and applies only to supply from an outside source.

At week-ends, holiday periods, stoppage of work from accident, or labour troubles, there are undoubted advantages in being able to run any individual motor when necessary without running a generating station. This advantage is more marked in the smaller single-pit installations than in those of larger capacity dealing with a group of pits.

Apart from special arrangements to meet abnormal conditions, current is usually charged on one of the following methods: (1) Flat rate, *i.e.*, a uniform rate for all current consumed. (2) Differential rate, *i.e.*, two distinct flat rates in force, one applying to certain hours only, the other to the remaining hours. In practice the proposal usually is for a certain rate for day-shift, and one appreciably lower for night work and week-ends. (3) Maximum Demand. This also consists of two separate items, viz. (*a*) a fixed charge per kilowatt demanded per month, or per year; (*b*) a further rate per unit for all current consumed.

To each of these three methods of charge a coal variation clause is generally added, whereby the rate per unit varies according to the market price of coal.

The cost to the supply company of furnishing the same amount of current to two different consumers may differ to a very wide extent. For example: Consumer A uses 10 kw. 10 hours per day; consumer B uses 100 kw. 1 hour per day. Each will use the same number of units, but to supply B's need the station must have available 10 times the power required for A, therefore the total charge to B ought to be greater than to A.

Stating the proposition in more general terms, equitable tariffs should: (*a*) Ensure the supply company a reasonable return on the capital expended to meet that demand, and on the cost of production; (*b*) provide that each consumer should obtain his supply on the most favourable terms, and should only pay his own proportion of the cost.

For general supply the maximum demand system is undoubtedly the most satisfactory, is equitable to supplier and consumer, and has been largely adopted. By many, however, it is considered difficult to follow, and more or less wrapped in mystery. In principle it is extremely simple—the M.D. rate is designed to cover the supply company's fixed charges for furnishing, not the possible, but the actual, demand made. The rate per unit similarly covers, or is intended to cover, running costs, the main item being fuel.

In practice the period for which the M.D. is measured is generally 15, 20, or 30 minutes, and, assuming the accuracy of the control clock, is always the same period; that is to say, on 15-minute lag from 9 to 9-15, 9-15 to 9-30, and so on, and never 9-5 to 9-20, 9-20 to 9-35. The instrument really measures the actual number of units passing in the period of lag, and further multiplies the total by the correct factor (4, 3, or 2 for 15, 20, or 30 minutes) to bring the result to an hourly basis. It carries a dial with a needle, which shows the highest maximum demand previously registered; such indication remains until a higher maximum demand occurs, when the needle is moved forward accordingly, or until the instrument is reset to zero.

*(To be continued.)*

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RUSSIA: GREAT ELECTRIFICATION EXTENSION FORESEEN.—The Russian engineer, P. Gurievitch, writing in the *Viestnik Finansoff*, on the metallic requirements of Russia, makes the following observations in respect of copper, etc.:—"A great consumer of metals, particularly of copper, will, amongst others, be the electrical industry, for which naturally a brilliant time is expected after the war, when the need for working cheaply and economically will be extreme. This will become possible within existing narrow limits chiefly by the electrification of factories and works, railways, etc., by the use of water power, brown coal, and so on."

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THE COALFIELDS OF NORTH-WESTERN FRANCE.—Judging from the tone of a recent discussion in the Prussian diet, the Germans attach great importance to the rich beds of coal and iron in French Lorraine. Of these, the basins of Briey and of Longwy, in the Department of the Meurthe and Moselle, are the most important. The former are situated about 30 miles east of Verdun, near Metz, whilst those of Longwy, further north, are near the Belgian frontier. Some idea of the importance of the coal districts in the Briey district may be formed from the following figures given recently by the *Economiste du Littoral*, a financial paper, published at Nice. From these it appears that the output of the 17 principal coalmines in this district was during the two years preceding the war—1912, 12,532,240 metric tons; 1913, 14,823,740 metric tons, showing an increase of 2,291,500 tons in 1913, as compared with that of the previous year. The total quantity of coal raised in this district and sent to Germany, and lost to France, cannot be less than 15 million tons at the present time. It is also probable that the output of iron ore, which previous to the war was very important, has not fallen off, and that the quantity sent to Germany at the present time far exceeds the production of the pre-war years.

## ADDRESS BY MR. MICHAEL LONGRIDGE TO THE INSTITUTION OF MECHANICAL ENGINEERS.*

In the circumstances of to-day a review of developments and inventions of the last 50 years would hardly be a suitable subject for a Presidential Address. Its scope would be too narrow. Our minds are occupied with matters of far greater moment than the developments of power plants for driving mills and works. They are fixed upon the war, and the evolution that must follow it. I shall ask you, therefore, to look back for a moment on the past, to view it from the standpoint of to-day—the retrospect may give some clue to the causes of our failures—and then I want to mention some of the things which we have done to repair our losses and some of the many we have yet to do.

When our Institution was founded in 1847, mechanical engineering, together with the other industries it served, was rapidly acquiring that pre-eminence which was soon to earn for England the title of the Workshop of the World. The mechanical engineer was favoured by circumstances of time and place. The country's natural wealth in coal and ironstone had supplied him with the raw material of his trade. The improvement of the steam engine by James Watt had given him power to drive his works. The evolution of the locomotive and the railway by George and Robert Stephenson had provided cheaper and more rapid means of internal communication than were available elsewhere. The application of steam power to navigation initiated earlier in the century by Robert Fulton and Henry Bell, the numerous harbours on our coast, and the protection of a Navy supreme upon the seas, facilitated and safeguarded trade abroad. Finally, the abolition of the corn laws, if it devastated agriculture and hazarded the safety of the nation, undoubtedly assisted the mechanical engineer, first, by driving the rural population to the towns and thus providing labour for the workshop, and, secondly, by enabling foreigners to become his customers by paying for his productions with their corn. The extraordinary expansion of the cotton trade following the inventions of Hargreaves and his fellows, and the substitution of iron for wood in shipbuilding, also brought no small prosperity to the mechanical engineer. With such advantages it is not surprising that before our Institution came of age England had won the title she has now for a long time lost.

In winning this title she was transformed from an agricultural and practically self-supporting nation into a manufacturing community dependent for its existence, as we realise too well to-day, upon imported food.†

And as the mechanical engineer was responsible in no small measure for the transformation, so he must be held responsible for the maintenance and efficiency of the workshop on which the feeding of the people and the defence of the people against their enemies now depend. He became and he remains a trustee for the British Empire. How did he discharge the trust?

Let me unfold the story of the engine-building trade of Lancashire. There was a time when shops were many and full, when Lancashire steam engines were sent wherever steam engines were used, when Lancashire's supremacy in this branch of engineering was beyond dispute. In 1900 I went to the Paris Exhibition. I went there primarily to see the stationary engines, whose claims in the matter of steam consumption were beginning to attract attention here. In elegance of form, in completeness of finish, in careful arrangement of details, the engines exhibited by some of the Continental makers excelled any I had seen before. The British stationary engines, small in size and number, slovenly in finish, makeshift in the fitting of accessories, proclaimed to seeing eyes the dangerous excellence, not to say superiority, of the foreign work.

Ominous as the exhibition was, it failed so far as I could see, to produce any important changes in the practice of British engine-building firms. Nor is this very surprising. Those in authority in the drawing offices and works were still men trained exclusively in the shops. The "produce of the technical school" was still widely held to be a useless, if not a noxious product, and perhaps in the early days of technical education his training did not make for easy correspondence with his new environment.

In the nineteenth century few British engineers were able to guarantee the steam consumption of their own steam engines. To-day most contracts contain consumption guarantees. If these guarantees are not so low as those obtainable abroad, I think their fulfilment sometimes falls less short of promise.

Most other branches of mechanical engineering have suffered more or less from foreign or American competition. Some of the causes of our relative retrogression are beyond the control of engineers, others they can remove in part or altogether, and of these I think inefficient technical education, lack of trade organisation, and the policy of the trade unions claim special attention.

### Technical Education.

In the early days of our Institution most engineers were trained entirely in the shops. Theoretical knowledge was uncalled for and even held to be antagonistic to practical success. There was no supply of scientific engineers, partly because there was no demand, and partly because the places where a man could study the theoretical side of his profession were few and far between.

It was not till 1877 that the Livery Companies in London, belying the popular idea of their activities, appointed a committee to consider the possibility of initiating a National scheme of technical education. The City and Guilds Central College was the result. Its foundation in 1880 marked the first public recognition of the need of something more than office or workshop training for the engineer. Then came the appointment of the Royal Commission, which reported in 1884, the formation of the National Association for the Promotion of Technical Education in 1887, and the Technical Education Act of 1889, which refused to the schools it governed the means of teaching the practice of any trade. In 1890 only was a real foundation laid by the transfer of the control of technical education from the School Boards to the local authorities, and the appropriation of half the "whisky money" for its support.

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* Abstract of Presidential Address before the Institution of Mech. Engineers, April 20th, 1917.

† Wheat consumption of the United Kingdom:—

| Year. | Home grown. | Imported. |
|---|---|---|
| 1842 | 22,000,000 quarters | 2,970,000 quarters |
| 1914 | 7,300,000 „ | 29,220,000 „ |

The result has been a vast expenditure on technical schools. Nearly every local authority has built one. These schools range from the technical school of the small borough, where engineering instruction is limited to evening classes, to institutions of university rank like the Municipal School of Technology in Manchester.

Besides these we have provided engineering courses in most of our older universities, and endowed new ones, where science enjoys more prestige than Greek. To Oxford, Cambridge, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin, Durham, London, we have added since the foundation of this institution, Manchester, Wales, Birmingham, Liverpool, Leeds, Sheffield, Bristol, Belfast, and the National University of Ireland.

With all these schools and colleges it might be thought that the problem of educating engineers and engineering workmen had been completely solved. Unfortunately it has not. Our innate conservatism ties us too much to the traditions of the past. Many still fail to understand that the manual training which enabled an apprentice to become a master craftsman in times gone by, does not suffice to turn a schoolboy into an engineer to-day. The functions of the engineer and craftsman are entirely different, and their training must be different also. Moreover, differentiation is needed in the training of the various classes of engineers and workmen. This lack of differentiation seems to be one cause of the inefficiency of our technical education relatively to its cost. Another certainly is insufficient preparation of those entering the technical schools.

There are many Englishmen of the best type with initiative, ability to organise, and power to lead and manage men, yet really incapable of assimilating much book learning, especially higher mathematics. Do not let us make the mistake of forcing these men through the same collegiate course as men of different mentality, and then passing them on examination with a low percentage of full marks. It would be infinitely better for everybody to keep them to more elementary work and require a high standard in examination. We must not underrate these men in our new-born zeal for scientific formulæ. Many of them are of our very best. The Institution recognises their value by admitting them without examination at 30 years of age. I hope the rule will not be changed.

My chief complaint is against the obstinacy of our two most famous universities in retaining Greek as a compulsory subject in their examinations. This reacts upon our public schools, and is a serious handicap on those who, intending to deal with the concrete rather than the abstract in their future lives, yet wish to find their level in the social life and moral discipline of these two universities.

The education provided for the workmen, on the other hand, both general and technical, is most unsatisfactory. Trade apprentices who enter the shops at 14 years of age, and sometimes earlier, seldom have subsequent opportunities for learning other than at evening classes. Some are resolute enough to attempt brain work at the end of a day beginning between 5 a.m. and 6 a.m., and some are strong enough to profit by their attempt. The majority are not. I have seen in some paper that technical education in England and Wales is provided in 6,876 evening and similar schools, but that the average attendance is about one hour per week.

*(To be continued.)*

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# EDITORIAL.

## MOTOR TRACTOR DEVELOPMENT.

Road traction, so far as it relates to pleasure service and to the heavier services rendered by the motor lorry, has developed wonderfully in recent years. The march forward was very great before the advent of the war, and as regards the heavier side, has been still greater since the war began, but particularly for military service and for civil services connected with the manufacture of munitions. On the other hand, although many light and medium-sized chassis have been employed in general service for the lighter class of commercial loads, there has been comparatively little development in this country of the lighter form of road tractor, that is, a tractor designed chiefly to pull a load. In some directions light steam-driven tractors have been employed with very great success, as, for instance, in taking produce from the country to London markets, but so far as we are aware, this form of traction has not been employed, at any rate not to a great extent, in any other district of the country. We should have thought, for instance, that this form of traction would have found very great favour with Cheshire farmers, and particularly those who regularly send their produce to the great Manchester markets. The roads, as is well known, are as fine in the County of Chester as in the best of other counties, and those which lead into Manchester are comparatively level. At any rate, there are no gradients so serious that a motor tractor with a decent load would not easily overcome them. In our view, there is a great future for the tractor with its ability to pick up loads and leave them at a destination to be unloaded whilst coupling up to another load and proceeding back again. The tractor has also the advantage over the motor lorry in many services in that it is generally handier and can deal with loads in situations difficult for the heavier type of vehicle.

*Apropos* of this subject, we hear that Mr. Henry Ford's chief engineer, Mr. C. E. Sorensen, is now in this country, and is said to be making arrangements for the production of motor-tractors on a very large scale. What this means can be quite readily understood. There is no gainsaying the fact that if the Ford enterprise takes up tractors they will be made cheaply, with plenty of power and in great quantity. This is the keynote of their light car construction, and doubtless it will be followed in what is now proposed to be done. It would look as though our friend Ford was going to be a pioneer in another direction in this country, as he was in the construction of light and powerful motor-cars for general purposes. We wish him every success in his enterprise, for, in common with engineers generally, we cannot afford to exhibit jealousy where the advance of engineering is concerned. U.S. Ford's enterprise should act as a stimulus to motor engineers in this country to imitate his example, and go one better, if possible. That way and that spirit leads to success. Meantime, of course, our motor builders are entirely engaged on work for the war services, and consequently there is some real excuse this time for not going forward at present. However, someone at least will have time to be thinking out things and laying plans for the future, to take shape immediately the war shows signs of cracking up. Probably the greatest development for the motor tractor will be in the direction of farm-work, the introduction having already taken place in the greatly-increased employment, for instance, of motor-ploughs, both self-contained with the motor and hauled along by a tractor. Experience has, therefore, already been gained in their use, and an extension in this direction is almost a foregone conclusion.

# COAL GAS AS A FUEL FOR MELTING NON-FERROUS ALLOYS.

By George Bernard Brook.

(Lecturer in Non-ferrous Metallurgy in the University of Sheffield.)

*(Continued from page 312.)*

(2c) *Life of Crucible.*—As far as can be gathered from the experience of practical men, one of the greatest disadvantages of the gas furnace is the short life of the plumbago crucible under the "cutting" influence of the flame.

The results of the author's experiments show that the wear and tear on the crucibles is not only contrary to this opinion, but that the crucibles had a longer average life in the gas-fired than in the coke-fired furnace. It was found possible to get as many as twenty-two heats and an average of 17·6, whereas the life of the same make of graphite crucible used for this alloy in a coke-fired furnace was found over a period of six months to average 12·5, exceptional crucibles reaching a maximum of sixteen heats. (See Fig. 5.)

(2d) *Life of the Lining.*—The length of life of the lining of the furnace is one of vital importance to the manufacturer producing high melting point alloys, and the writer fully expected to find this one of the weaknesses of the furnace. The results, however, showed that the lining had stood the test satisfactorily. The condition of the burner also was quite good, and no tendency to deterioration was noticeable. (See Fig. 6.)


Fig. 5.—Photo of Crucibles.

From time to time, as it seemed necessary, the lining was coated over with a wet ganister dressing, just in the same way that coke-fired furnaces are repaired each week.

(2e) *Mechanical Losses.*—The fact that the crucible in the case of the gas furnace rests on a level and the stable base plate, would lead one to expect that mechanical losses in charging and drawing would be less than in the case of coke. The percentage loss was found to be 0·40, and even this would seem to be capable of being still further reduced as the melter gained experience with the furnace. This represents a substantial saving compared with coke furnaces, as only with the best practice can the loss in the latter be decreased to 1 per cent.

Fig. 6.—Photo of Lining at End of Test.

(2f) *Labour Charges.*—On a large installation there would be a distinct advantage in favour of gas in the amount of labour required. Four coke-fired furnaces can be worked by three men. It would be possible to work a six-hole gas-fired battery with four men, even taking into account the extra mould preparation incident on the increased speed of gas melting. This would represent a substantial saving in labour charges.

(2g) *Capital Charges.*—The capital cost (exclusive of the actual building) for installing a battery of gas or coke-fired furnaces, capable of giving the same output:—

| | £ |
|---|---|
| Four pit-fired coke furnaces complete with separate flues and stack, 30 ft. high | 280 |
| Battery of four gas furnaces complete with blower, tank, and gauge, including cost of excavation, would be | 242 |

From these figures it will be seen that there would be very little difference in capital cost. The above are calculated on present war prices.

(2h) *Quality of Metal Produced.*—The working properties of industrial alloys must of necessity be the main

consideration from the manufacturer's point of view, and it is very satisfactory to find that the report of one of the largest cartridge factories in the country showed that the material melted in this test was of better quality and resulted in fewer failures than any in previous use. Up to the final operation of pointing the bullet sheath, not a single failure resulted out of the 30,000 cups taken for the test, and only in the last and most drastic operation of pointing was it found that 200 sheaths failed.

This represents 0·6 per cent, whereas the average failures from the best material are not less than 0·8 per cent. It may be added also that, in the opinion of the roller, the material was excellent.

### Conclusions.

From the results of the test the following advantages in favour of gas as a fuel may be summarised thus:—

1. The absence of dirt and accumulation of ashes.
2. The elimination of the difficult and wasteful process of "slagging."
3. Economy in fuel, in that between the pouring of each heat and the recharging of the pot the gas is cut off.
4. The lining may be easily and even temporarily repaired in the middle of the day's run.
5. The loss of metal resulting from the accidental breaking of the crucible would be far less and more easily recoverable than in the case of metal similarly lost in the coke-fired type.
6. The actual cost of fuel is less when gas was used.
7. The speed of melting is far higher in the gas-fired furnace, and therefore the output over a given period would be substantially greater.
8. The mechanical qualities of the metal were superior to the average coke-melted alloy.
9. The deleterious effects of sulphur and oxygen, which however careful one may be, are never absent in the case of coke-melted metal, and are less evident in the case of alloys melted by gas. This is shown by the analyses of the brass in the author's preliminary review, where the sulphur is only a little more than half that recorded for metal melted in the coke-fired type. Since the ideal flame used in the gas furnace is one only slightly removed from the reducing flame, it may be concluded that oxidation of the metal was reduced to a minimum.

*Relative Costs of Melting in Different Centres.*—Whilst the relative prices of gas and coke vary together, they do not do so always to the same degree in different districts.

The following prices may be taken as the averages in the districts stated. The relative costs of gas and coke melting are calculated on the figures found for gas and coke melting in the author's tests adjusted for each district:—

The calorific value of the gas used, based on the average of nine days, was 532 British thermal units (gross).

The cokes used showed an analysis:—

| | A | | B |
|---|---|---|---|
| Moisture ................ | 0·06 | .. | 0·59 |
| Ash ...................... | 7·96 | .. | 7·02 |
| Volatile matter ........... | 6·13 | .. | 3·01 |
| Fixed carbonaceous matter.. | 85·91 | .. | 89·81 |
| Sulphur.................. | 2·56 | .. | 1·23 |

The electrical energy required to run the blower during this test approximated 1s. 8d. per day.

The writer would like to acknowledge his indebtedness to Professor J. O. Arnold, F.R.S., for his valuable help and for granting the author facilities for carrying out the test; to Mr. A. J. Hartley, to Mr. W. Smith, and others who have so materially helped in the preparation of this paper.

*(Concluded.)*

## ELECTRIC SUPPLY TO COLLIERIES.

By G. S. Corlett, M.I.E.E.

*(Concluded from page 318.)*

Supply for collieries is usually furnished under special contracts for a term of years, and the following are the more important points to consider in connection therewith:—

### Guaranteed Revenue.

The broad principle of a minimum payment is generally adopted without question, but the details frequently prolong negotiations. The amount should bear some relation to the cost incurred by the supply company in delivering to consumer's premises.

Whether the payment should be cumulative or non-cumulative is open to argument. In a recent case a mile away from the nearest mains the calculated annual value of current at the rate offered was £1,800 per annum, and the supply company proposed on a 7-years' contract that payments should be guaranteed:—

At the end of 1st year not less than £1,000,
,, ,, 2nd ,, ,, £2,000,
,, ,, 3rd ,, ,, £3,000,

and so on. Hence, as soon as a total sum of £7,000 had been paid the consumer's liability for any further dead rent ceased.

In view of the uncertainty of mining operations a cumulative arrangement is best for the consumer and not unfair to the supply company, provided the amount be not too low.

### Period of Lag.

Choice of the length of lag is seldom available owing to the desire for standardisation on the supply company's part. In one instance within the writer's experience

| Town. | Special High Grade Coke, "Metallurgical," "Steel," &c. | Gas (minimum rate per 1,000 cubic feet). | Calculated Costs of Melting Cupro-nickel per Ton (based on ruling prices for fuel). Gas. | Coke. |
|---|---|---|---|---|
| Sheffield ........... | 40s. 3d. per ton. | 1s. 4d.* | 24s. 2d. (found). | 36s. 4d. (found). |
| | | 1s. 9d. | 31s. 9d. ,, | |
| Glasgow ........... | About 40s. per ton. | 1s. 5d. | 25s. 8d. (calculated). | 36s. (calculated). |
| Birmingham ....... | 45s. 6d. per ton | 1s. 5d. | 25s. 8d. ,, | 41s. 3d. ,, |
| London ........... | 50s. ,, | 2s. 8d. (Wandsworth, 2s.) | 48s. 4d. ,, (34s. 3d.) | 45s. 5d. ,, —— |

* For use in gas engines only.

alternative proposals were made for M.D. at 15 minutes' and 30 minutes' lag, and the rates were in the ratio of 80 per cent to 100 per cent. The shorter the lag the lower should be the ratio of M.D. charge. The load conditions determine, when a choice is possible, which is the correct procedure. In cases where the load is constant and a maximum for long periods, it is obvious that the demand will be identical for any time lag; hence the lowest rate should be adopted. Where the running machinery consists of intermittent working plant, such as main-and-tail haulages, it is equally evident that a longer time lag is desirable.

### Resetting to Zero.

Every agreement should specify clearly the times at which M.D. indicator should be reset to zero. Neglect of this point may considerably affect the annual cost. The arrangements vary to a large extent, as the following schedule of contracts now in operation show, and which provide for the resetting of the meters. (*a*) Monthly throughout the contract. (*b*) Monthly for first three years, then yearly. (*c*) Yearly throughout the contract. (*d*) At the termination of the contract, *i.e.*, a M.D. once established is never reduced.

Clearly method (*a*) is most favourable to the consumer, and (*d*) least favourable. A simple illustration will perhaps emphasise this point. Assume an M.D. rate of £4 per kilowatt-year and a steady day load of 50 kw. for, say, endless haulage and 50 kw. for night pumping. If from any cause such as carelessness on an attendant's part the two loads are run simultaneously, the extra costs will be:—

(*a*) For monthly resetting $\frac{4 \times 50}{12}$ = £16 13s. 4d.

(*b*) For yearly resetting 4 × 50 = £200.

(*c*) For resetting at termination, £200 per annum for each unexpired year.

While the responsibility for the correct running of this plant properly belongs to the consumer, he should not be unreasonably penalised for an isolated act. Provision ought to be made to meet such contingencies, and also to afford relief if the load be permanently reduced by, for example, closing a mine.

### M.D. Charges.

These are usually based on one of the following methods: (*a*) Fixed rate for all load. (*b*) Sliding scale, *i.e.*, a steadily decreasing charge for a steadily increasing load. (*c*) Semi-sliding scale, which really means that the first block of kilowatts (say 100 or 200) are charged at one rate, the next block at a lower rate, and all in excess at a still lower figure.

It is not necessary to point out that methods (*b*) and (*c*) afford an inducement to the consumer to increase his demand, and have doubtless been drafted with that object in view. The actual figures attached to the respective rates form the only basis for determining which method to adopt in any particular case.

### Coal Variation.

This applies only to the charge per unit metered, which is, of course, sound. Cost of coal of a certain calorific value generally, but by no means universally, forms the basis. It is essential that the basis should be clearly defined, and so stated that any competent engineer can, in the event of dispute, decide the matter at issue.

### Load Factor.

By this expression is meant the ratio of the actual units used to the possible units if the load was maintained uniformly. Thus one kilowatt-year = 8,760 units. If the actual units metered are 4,380 on a demand 1 kw., then the load factor will be

$$\frac{4,380 \times 100}{8,760} = 50 \text{ per cent.}$$

In the vast majority of colliery installations the higher the load factor the lower will be the running cost, and this applies whether supply be purchased on maximum demand basis or generated.

With purchased current the cost comes automatically in front of principals when the periodical account has to be dealt with, and variations not infrequently call for explanation. Whether that be so or not the cash value of any improvement in load factor can be ascertained definitely.

With generated current exact records are not always available, and the total monthly cost is seldom brought out, consequently approximate values can only be stated for the suggested alteration.

The writer is also aware that a low load factor in no sense justifies a suggestion of bad management on the part of the consumer, but he is equally sure that in many cases great improvements can be effected. The procedure to effect this can only be determined by consideration of actual conditions, and it is only possible to indicate in general terms one or two lines along which investigation is likely to be profitable. Since the day load requirements usually exceed those of the night, the problem may almost be narrowed down to the question of increasing the night load.

### Pumping.

Owing either to insufficient lodge capacity, or to the pumps being too small, electric pumps are often run for part of the day shift. In the case of the small typical installation referred to when discussing M.D. meters, if the reason for running he pump on day shaft was too small a lodge room, it is clear that the value of enlarging the standage is £200 per annum.

Again, by no means all colliery pumps are electrically-operated, and even in cases where the existing engines are reasonably economical, an examination may show that the general reduction in cost would justify the necessary capital outlay. Another possible source of night load is for coal-cutting, either direct or by motor-driven compressors.

### Linking Up.

If a group of collieries can be linked up and metered at a common supply point, and electricity purchased in bulk, savings may be expected—(*a*) From reduced rates owing to a larger demand. (*b*) From diversity factor. The resultant maximum demand from two collieries metered at one point cannot possibly be more than the sum of the two separate demands, and will almost certainly be appreciably less, and to an extent more than sufficient to warrant the expenditure on transmission lines.

### Conclusion.

The writer suggests that attention to the following points will fully repay the trouble involved: (*a*) Consider in advance the extent and incidence of initial and future loads. (*b*) Whether current should be purchased or generated. (*c*) If purchased, study contract provisions with reference to working conditions, and endeavour to improve load factor.

*(Concluded.)*

# THE APPLICATION OF COAL GAS TO INDUSTRY IN WAR TIME: ITS NATIONAL IMPORTANCE.

By Horace M. Thornton, M.I.Mech.E.

(Continued from page 305.)

## Examples of Canteens.

We will commence our illustrations with two examples of modest installations for supplying meals in small factories. The first slide shows a works kitchen providing meals for about sixty hands. This is quite a simple equipment, but adequate for the requirements, and doubtless a great boon to the workers. The installation illustrated in the next slide is a little more elaborate and caters for about one hundred workers daily. Still on the ascending scale, our next view is of a kitchen for about 250 people. Here the apparatus is naturally much larger and more varied. This kitchen provides meals for a department of one of the largest firms engaged in the motor industry, as to which it may be said that hardly any industry has done greater and better work for the country in these times. Our next slide shows the dining-hall. A factory of this magnitude would have several canteens, each to cater for a different department.

The next slide gives us a good idea of a slightly larger kitchen for 350 hands. The service counter can be seen and, on the right-hand side, a corner of the mess-room.

Now I want to show you several views of the kitchen and dining-rom of one of our largest manufacturers engaged on war work. This canteen is so well equipped, so excellently managed, so thoroughly patronised, and has produced such eminently satisfactory results, that it deserves a rather longer description.

The accommodation of the canteen is for 600 persons. The kitchen, as will be seen, has gas apparatus installed throughout, and the next slide shows another view, with gas-heated circulators, for supplying hot water (Figs. 14 and 15). This equipment provides daily: (*a*) Early tea and hot milk for night staff of 500 workers; (*b*) breakfast at 8 a.m. for 450 workers; (*c*) complete dinners at 11-45 a.m. and 1 p.m. for about 400 workers at each sitting; (*d*) teas for workers who come to the canteen; (*e*) over 120 complete teas sent out in batches to workers in different parts of the building; (*f*) suppers for night workers.

The next slide (Fig. 16) is a general view of the dining-room at one o'clock. The method of serving the principal meal of the day—dinner—may be briefly described. On entering the building the workers purchase from the pay desk vouchers or checks—one for meat and vegetables and one (of different colour) for sweets. The checks are handed in by the workers at the serving counter. No money is taken here, and the worker has only to indicate his preference for the different dishes on the menu. About two-thirds of the estimated requirements of portions of meat are carved beforehand, and placed in hot closets seen in the first picture. Vegetables, sweets, etc., are all dished up and placed at hand in convenient positions. By these means the whole 400 workers are served within ten minutes of entering the building. The next slide shows the dining-room at 1-10 p.m. (Fig. 17). The workers carry their own food to the tables, picking up forks, knives, and spoons from a table in a central position.

The tables are 2 ft. wide, solidly constructed, the tops being covered with white American cloth. The chairs are 15 in. wide, and about 20 in. is allowed at table for each person. The women workers have their dinner at 11-45 and the men at 1 o'clock, these times leaving sufficient interval for clearing up between the two sittings. The staff consists of a lady superintendent, two cooks, two assistant cooks, six waitresses to serve at counter, scullery maids for washing up, etc. A small stall is provided (seen on the right of the picture) for the sale of cakes, buns, sweets, tobacco, etc. The artificial lighting is by incandescent gas burners throughout and the heating by gas-steam radiators, one or two of which can perhaps be discerned at the extreme left-hand side of the picture. An example of one day's menu with prices may be of interest:—

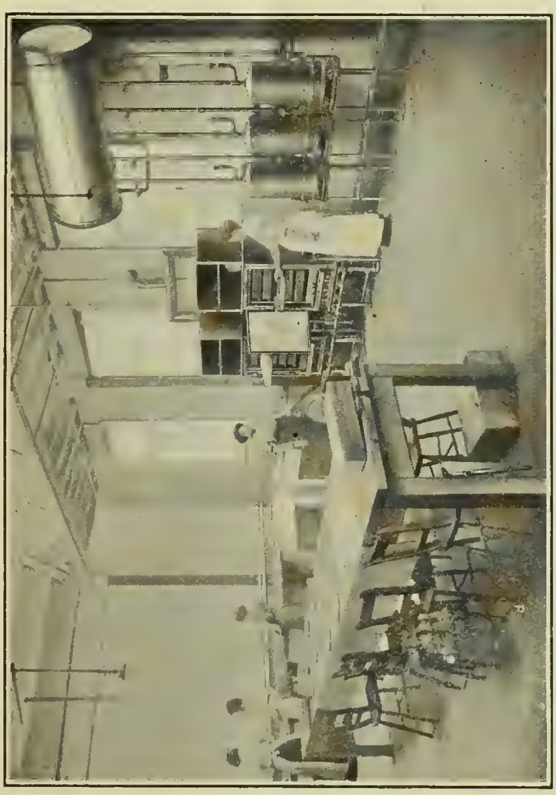


Fig. 15.—Kitchen, showing Gas-heated Circulators for Supplying Hot Water.

Typical Menu at Large Works Canteen.

| | |
|---|---|
| *Monday.* | |
| Roast Beef or Roast Mutton, Onion Sauce, Beans, Potatoes | 9d. and 7d. |
| Sago Pudding or Fig Pudding | 2d. |
| *Tuesday.* | |
| Bean Soup (with bread) | 3d. |
| Hot Pot | 6d. |
| Sultana Pudding or Prunes and Custard | 2d. |
| *Wednesday.* | |
| Roast Beef or Roast Pork, Apple Sauce, Peas and Haricots | 10d. and 8d. |
| Rice Pudding or Currant Roll | 2d. |

I may add I have submitted this menu to the Minstry of Food, who express their approval of it, with the exception that the puddings should be made of maize or barley meal.

At these prices the canteen, by careful management and scrupulous attention to detail, is self-supporting, the cost of the building and equipment having been borne by the firm. A corresponding canteen, not quite so

large, catering for about 300, and installed at another of the works of the same firm, is seen in our next slide. teen. This company has endeavoured to study the comforts of their employees in a great variety of ways, and

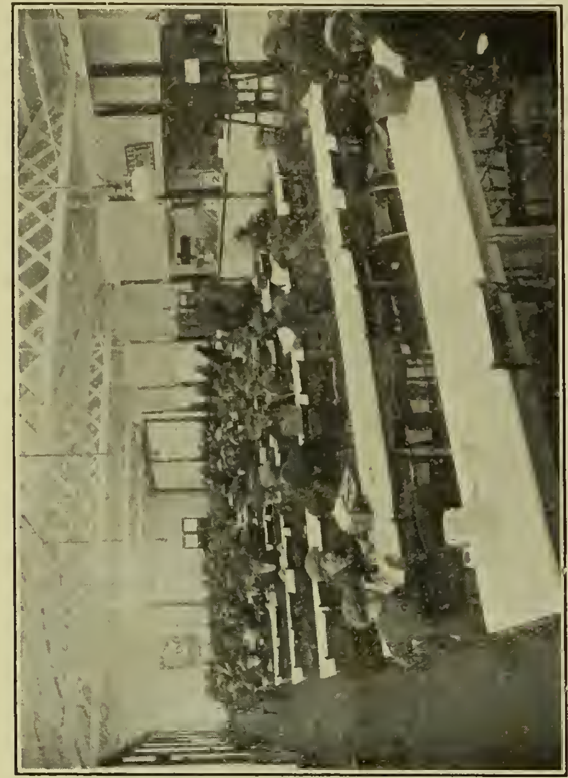


Fig. 17.—View of Dining Room (Fig. 16) at 1-10 p.m.

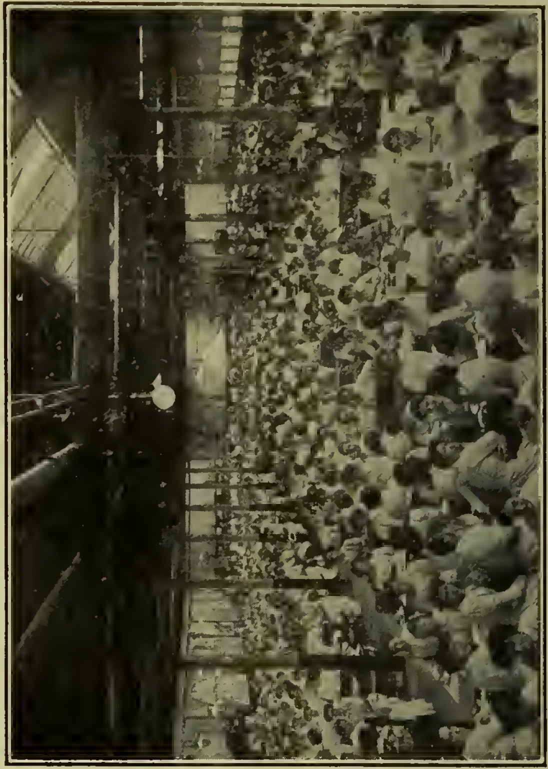


Fig. 19.—Another Large Dining Room.

Fig. 16.—Dining Room at Large Works at 1 p.m.

Fig. 18.—Exterior View of a Canteen.

The view is of the dining-room, and the prevailing airiness, lightness, and aspect of comfort will be noted.

The next picture (Fig. 18) is of the exterior of a canteen. the photograph, taken from the bowling-green, is some evidence of their consideration. The interior of the splendidly fitted kitchen provides our next picture.

The measure of the value of a canteen is the extent to which it is patronised by the workers, and this slide shows us part of the dining-room of a factory, filled to its utmost capacity. Two thousand workpeople take their meals here daily. The next picture is of another large dining-room, and proves there is no doubt as to its popularity among these work-girls (Fig. 19). I have referred previously to the usual method of serving meals, and the slide now shows a service counter—the girls collecting their own dinners and carrying to the tables.

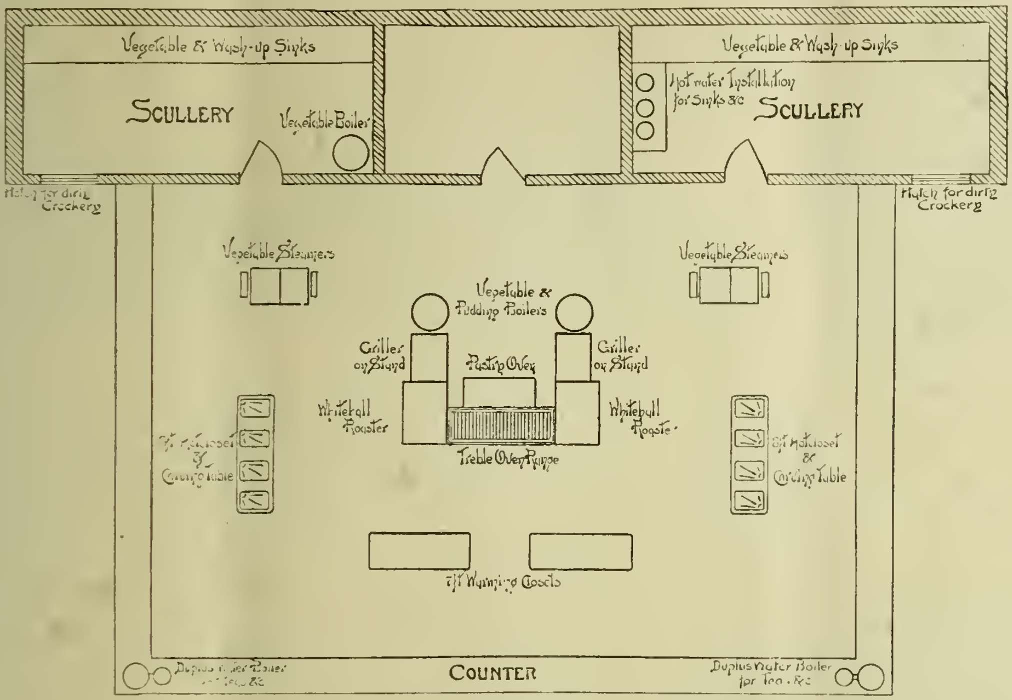



FIG. 20.—GROUND FLOOR PLAN OF A KITCHEN.

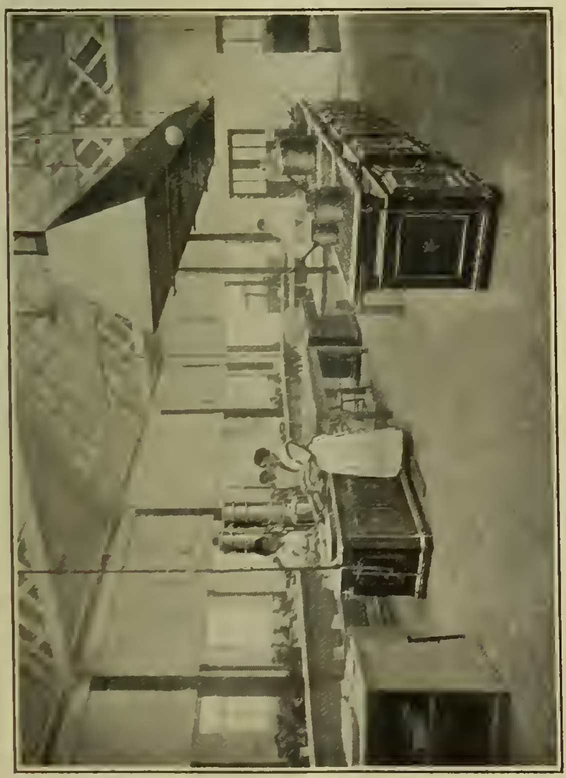


FIG. 21.—GENERAL VIEW OF A KITCHEN AT A LARGE LONDON WORKS.

FIG. 22.—GAS APPARATUS FOR BOILING WATER.

The provision of ample supplies of hot water is essential for good working. You probably noticed the gas-heated circulators on the screen just now, and this is a nearer view of another battery which provides hot water

for a large number of taps. The gas consumption is automatically controlled, so ensuring great economy in use.

The arrangement of the apparatus in the kitchen is of immense importance. The next slide (Fig. 20) gives a ground-floor plan of a kitchen for providing for approximately 850 hands. The apparatus must not only be well-designed, but so situated that both in preparation and in serving there is no waste of time, and no impeding of one operation by another. "Speed" and "economy of labour" are great watchwords in industrial canteen work.

The last pictures on this topic are of a very elaborately-equipped canteen at the works of a large firm near London. This is a general view of the kitchen (Fig. 21), which is centrally placed in the dining-room, serving dinners for about 1,000 workers. An additional 500 employees bring their own food to be warmed up. The next illustration gives a closer view of the kitchen; and some of the large and massive gas apparatus can be seen.

The provision of tea, coffee, and cocoa for workers is sometimes associated with, and sometimes separated from, the general canteen work. Also in factories where, for various reasons, it has been decided not to instal a complete canteen, it will be found a general practice to supply at least tea, cocoa, hot milk, etc. This is highly appreciated by the workers—especially by female employees, of which the number has so enormously increased—and conduces in a high degree to maintaining general efficiency. The Health of Munition Workers Committee strongly recommend the practice, and in works carrying on certain industrial processes entailing special risk of disease the Ministry of Munitions stipulate that this provision shall be made. The picture before you, Fig. 22, shows a large gas apparatus for providing instantaneous supplies of boiling water in one factory. The large storage cylinder combined with a powerful boiler enables 500 pots of tea to be made in a few minutes. The next slide is another type of boiler more suitable for supplying intermittent requirements.

The result secured by, and the advantages accruing to, both employers and workers following the establishment of factory canteens have been very impressive. They are summarised as follows by the Canteen Committee of the Central Control Board:—

*Direct Benefits.*—(1) Marked improvement in health of workers. (2) Less Sickness. (3) Less absence and broken time. (4) Less tendency to alcoholism. (5) Increased efficiency in output.

*Indirect Benefits.*—(1) Saving time of worker. (2) Salutary change from workshop. (3) Greater content-time.

The photograph now on the screen is evidence of the trend of the times. It is of a poster to be seen on the workshop. (5) Increased recreation and games in spare walls of a northern factory, and you will observe the provision of dinner facilities is one of the inducements held out to secure employees.

The opinion of employers who have had experience of canteens on a large scale is markedly favourable. The Chief Factory Inspector says:—

"It is gradually being recognised that the physical fitness of the worker has an important bearing on the output of the factory, and so it is to be found that dining-rooms and restaurants are slowly becoming more general, more especially in the modern and most up-to-date factories, and in those so situated that the workers cannot return home readily for their meals."

He adds:—

"The experience of a Bristol firm is most instructive on this point. They have no less than five restaurants in one group of factories, each large enough to accommodate 1,000 people, and the meals are provided by the employers at cost price or slightly below it. The first restaurant was started five years ago for one department only, and it was observed that a gradual reduction in the sickness rate in that department followed, until eventually it fell to one-half the amount experienced previously, when the bulk of the workers had not the opportunity of obtaining a good mid-day meal. Similar results were experienced when the restaurants were extended to other departments."

We may well conclude this brief account of a movement possessing wonderful potentialities by another quotation from Mr. Lloyd George:—

"I am delighted to see these canteens springing up throughout our workshops. They make an enormous difference. That men should get their meals, not in the old, squalid, uncomfortable conditions but in conditions which are in themselves attractive and healthful, is better for the working-man and for those who are in charge. It is better for all, and certainly better for the State. We are making a better country because we have the recognition that the interests of one section of us are the interests of all."

I should like to have continued and told you of the uses of gas in many other departments of welfare work—such, for example, as the important subject of good illumination, which is adequately provided by the use of incandescent gas burners; and of the provision of washing facilities and baths where gas-heated circulators provide the necessary supplies; and of the rest-room heated by the hygienic gas fire; and of the first aid post, with its gas-heated geyser for hot water, etc. Time, however, prohibits detailed references to these subjects.

These, then, are some of the ways—representative of numberless others—in which gas has served the community in war time, and I am sure you will agree with me it is no mean record that it has produced. And yet the story is not complete.

*(To be continued.)*

## THE PATERSON OIL ELIMINATOR.

[THE PATERSON ENGINEERING CO. LTD., WINDSOR HOUSE, KINGSWAY, LONDON.]

IT is a well-known axiom that oil and water will not mix. They have not, as it were, much brotherly love for each other, and are, in consequence, more or less at variance or in strained relationship. Whilst it may be desirable to mix these two ingredients in some industrial operations, there are others in which the elimination of the oil from the water is not only desirable but absolutely essential. After steam, for instance, has been used in the cylinders of engines, it leaves the latter in company with a portion of the oil which has been used for lubricating purposes, and the water of condensation which results is subsequently returned to the boilers very often with a portion or the whole of this oil still in it.

### Danger of Oily Water.

Now the danger arising from feeding oily condensed steam into high-pressure boilers is evidenced by the refusal of insurance companies to undertake the risk under such working conditions. A thin coating of oil

on the heating surface is decidedly more dangerous than a thick coating of scale. The oil prevents the water from coming into contact with the plate, which is overheated to a plastic state, causing bulging, as, for instance,

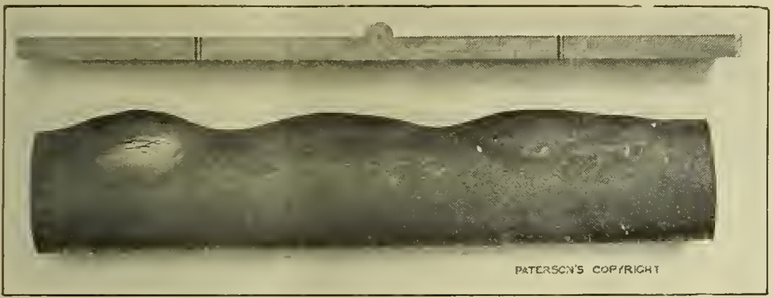



Fig. 1.—Bulges caused by overheating, due to the presence of oil in the feed water.

as shown in Fig. 1. The effect is cumulative, as the bulge is exposed to intensive heating and the charred remains of volatilised oil form a suitable collecting surface, causing further overheating, with final rupture of the tube, or collapse of the furnace crowns.

### Value of Condensed Steam Minus Oil.

Condensed steam, when freed from oil, forms an ideal feed water. It is soft and free from all scale or corrosive properties and contains valuable heat units. It is, however, of the utmost importance that the last trace of oil be eliminated. One of the most, if not the only satisfactory, method is to coagulate the emulsified oil globules into flocculent masses, which can then be removed by efficient filtration.

### Effect of Oil in a Boiler.

Sir A. J. Durston, K.C.B. (late Engineer-in-Chief to the British Navy), found by evaporation tests that with clean


Fig. 2.—Specimens of water. No. 1, Greasy Condensed Steam. No. 2, Greasy Condensed Steam after passing through finest chemical filter paper.

plates the difference in temperature between the plates and the water was 85 deg. Fah. With a greasy deposit $^1/_{16}$ in. thick on the bottom, this difference rose to 161 deg. Fah., and when this layer of grease was spread up the sides of the boiler the temperature of the plate rose to 617 deg. Fah., showing a difference of temperature between the boiler plate and the water of no less than 537 deg. Fah.

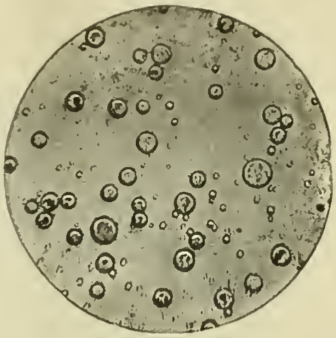


Fig. 4.—Photomicro of greasy condensed steam before treatment.

He further determined that a great wastage of heat occurred, and reported:—

"The results of the experiments showed that a thin coating of grease deposited on the tubes during the ship's trials caused a loss in efficiency as heating surface compared

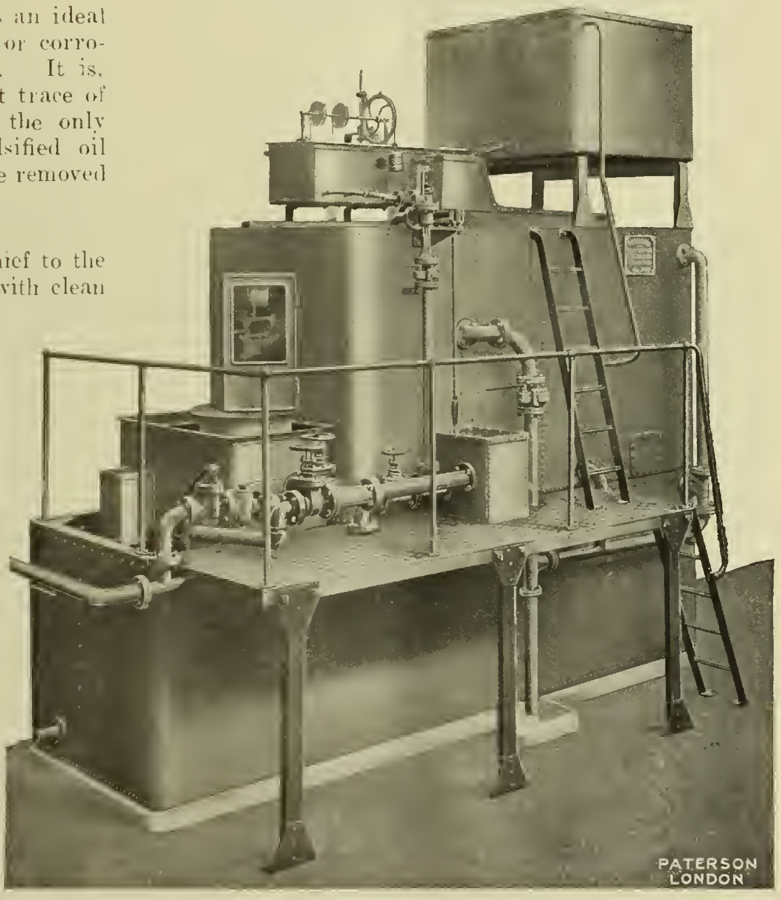



Fig. 8.—Paterson Oil Eliminator. ("A" Type with quartz sand filter.) Fitted with Paterson "Fluxograph." This is a typical installation for power stations, the oil eliminator being carried over the feed pump suction tank, making a very compact arrangement. A "Fluxograph" is fitted for recording the total amount of feed water evaporated throughout the day.

to perfectly clean tubes of 8 to 15 per cent, the mean of many experiments giving 11 per cent."

Mr. C. E. Stromeyer, Chief Engineer to the Manchester

Steam Users' Association, in a paper on "Distortion in Boilers due to Overheating," states:—

"A film of grease $^1/_{100}$ in thick offers resistance to the passage of heat equal to a steel plate 10 in. thick. In other words, grease offers 1,000 times the resistance of steel to the passage of heat"

Many theories have been advanced to account for this.

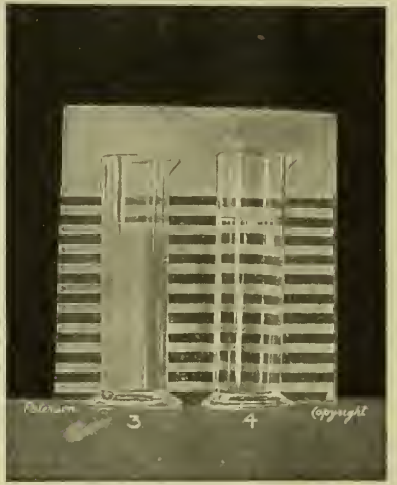
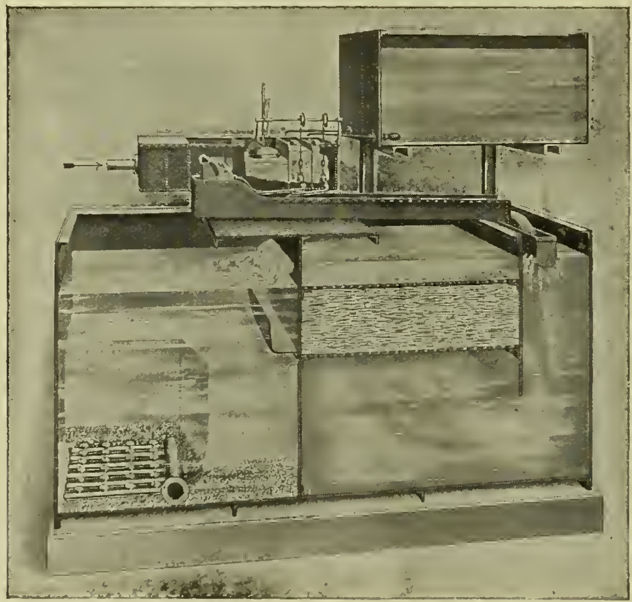



Fig. 3.—Specimens of Water. No. 3, Greasy Condensed Steam after coagulation and before filtration. No. 4, the same, as discharged from the Paterson Purifier.

The latter authority quoted suggests overheating and bulging in boilers coated with grease is due either to some "water-hammer" action connected with boiling or to



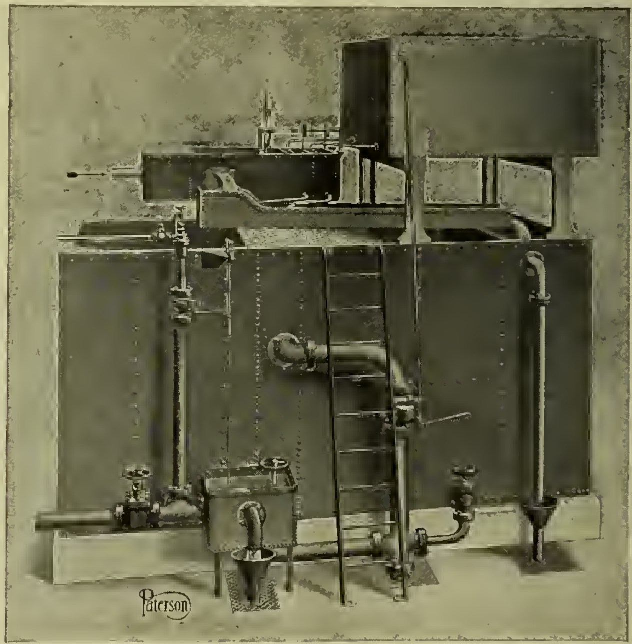



Fig. 6. Paterson Oil Eliminator (Type "A" with Quartz Filter). Fig. 7.

"retarded ebullition," which implies that the water is superheated, and causes local excess of temperature and pressure. He says:—

"One explanation offered is that a thin film of grease, if heated in a boiler, rises off the plate in the form of blisters, filled either with oil vapour or superheated steam."

Another possible explanation may be that oil on the boiler plate prevents the water from coming into actual contact with the metal so that radiation is the only means of heat transference. Water in the spheroidal state (as on a red-hot plate) is analogous.

### Futility of Attempting to Remove all trace of Oil by Exhaust Separators.

Oil separators between the engine and condenser perform a useful service in preventing the bulk of the oil from depositing in the condenser, but no separator on the exhaust main can remove all trace of oil from the steam, and nothing short of total elimination should be tolerated.

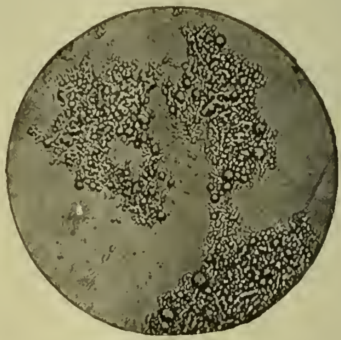


Fig. 5.—After coagulation by the Paterson Process and before filtration.

The temperature of high pressure superheated steam is sufficient to volatilise part of the oil, which remains as a vapour, and only condenses with the steam. The velocity of exhaust into a condenser averages 100 miles per hour. In a liberally-designed separator this may be reduced to 10 miles per hour, but even at this low velocity it is impossible to separate the vapour of oil from that of water.

The increased difficulty of removing oil from exhaust steam, when working with a high vacuum, is readily explained by the greater velocity of flow under such circumstances. At atmospheric pressure the volume of 1 lb. of steam is 37 cubic feet. With a vacuum of 25·8 in. it is 166, and at 27·8 in. 389 cubic feet; thus two inches extra

vacuum has more than doubled the volume of the steam, and consequently its velocity of flow through the separator.

### Simple Filtration Ineffective.

The general impression that the very fine oily matter can be removed by simple filtration is a complete fallacy. The oily particles will pass through the finest filter. Microscopic examination of greasy water shows that the oil globules some of which do not exceed 1/100,000 of an inch in diameter) are individual elastic spheres occasionally clustered together in groups, not unlike "fish roe." (Fig. 4.)

In the Paterson Oil Eliminator the elimination of these particles is effected by the addition of sulphate of alumina as a coagulant. Fig. 6 shows the result of this treatment. It will be noticed that every oil globule is caught and imprisoned in the flocculent precipitate, and can readily be removed by filtration. A sample of water as discharged from the Paterson Oil Eliminator when examined under the microscope reveals no trace of oil; not a single truant globule is visible, but only a clear spotless disc.

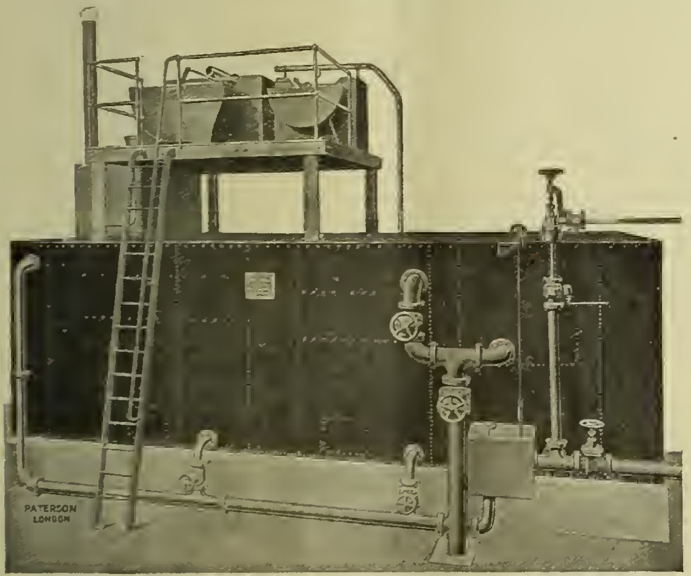



Fig. 9.—Oil Eliminator with Make-up Softener.

### Type "A" with Quartz Filter.

The oily condensed steam (direct from the air pumps or an auxiliary lift pump) enters the measuring chamber (Figs. 6 and 7) and overflows through a rectangular or V-notch discharge weir. A large float resting on the water in this weir chamber controls the position of two long tapered valves, giving annular orifices discharging the reagents in accurate proportion to the amount flowing over the weir. The reagents used are sulphate of alumina for the coagulation of the oily particles and soda ash for the neutralisation of the alumina, a constant "head" of these reagents is maintained above the valve seatings by ball valves piped to storage tanks of sufficient capacity for a full day's run. The greasy water and the reagents are thoroughly mixed in the baffling trough before passing into the reaction and precipitating tank where the bulk of the coagulated impurities is arrested by filtering upwards through wood fibre, final purification being effected by downward filtration through quartz sand.

The wood-fibre strainer removes practically the whole of the impurities when the plant is first started to work, but in time its meshes become choked. The increased velocity of flow tends to carry the impurities forward, but these are arrested by the quartz sand filter, which ensures at all times a perfectly clear water, and obviates the necessity for keeping such a vigilant watch on the condition of the wood fibre. Under no circumstances can the oily impurities be forced through the quartz filter, and it is this invaluable feature which has led to its extensive use for the critical duty of removing all trace of oil from feed water.

The filtered water is collected by the manifold strainer system communicating with the main outlet duct. The total area of the strainer throats is less than that of the main outlet duct, ensuring a uniform rate of draw-off over the filtering area, and equal distribution of the wash water during the cleansing process. This is effected by agitating the sand with compressed air from a steam air injector and flushing the loosened impurities to the drain by a reverse current of wash water from the main or other source of pressure supply. Ten minutes daily is sufficient to complete this washing process and restart the filter.

The outlet valve, controlled by the float above the filter bed, retains a uniform head of water above the sand by only permitting discharge at the same rate as entry. During the wash-out process this valve closes automatically, and reopens on filling up, preventing furrowing of the bed and excessive speed of filtration. The condition of the filtered water can be seen as it flows through the inspection box. The cost of treatment does not exceed one-halfpenny per 1,000 gallons, and the loss of temperature between the inlet and outlet averages not more than 5 deg. Fah.

The Paterson oil-eliminating plant at Summer Lane Generating Station, Birmingham, is believed to be the largest of its kind in existence, having a peak load capacity of 800,000 lbs. of condensed steam per hour. The plant was installed under guarantees that the cost for chemical reagents should not exceed ½d. per 1,000 gallons treated; that the drop in temperature between inlet and outlet should not exceed 5 deg. and that the effluent should be free from any trace of oil. According to the statement of Mr. R. A. Chattock, the Birmingham city electrical engineer, it was found in actual working the cost of reagents was ·169d. per 1,000 gallons treated, the drop in temperature was less than 5 deg., and the treated water was absolutely free from trace of oil.

### Oil Eliminator with Make-up Softener.

This combined oil eliminator and make-up softener, Fig. 9, is a most useful type of plant where surface condensers are installed, and the make-up water contains scale-forming salts. In the majority of cases the make-up is approximately 10 per cent of the total boiler feed supply, and while it is necessary that this should be softened it is desirable to avoid the complication of having separate plants.

The plant illustrated has a capacity of 5,500 gallons per hour of condensed steam, and 1,500 gallons of hard make-up water. It is also fitted with a shower heater for recovering the heat units in the exhaust steam from the feed pumps, and other small non-condensing auxiliaries. Where the make-up supply approaches 40 or 50 per cent of the total feed, as it does in stations combining surface and jet condensers, it is preferable to have a separate plant for each process.

The Paterson Engineering Co. Ltd. are specialists of high repute in the matters here treated and in the kindred subjects of water filtration and softening and exhaust heating. Our readers interested in these lines would do well to communicate with them.

## METAL MELTING AS PRACTISED AT THE ROYAL MINT.

By W. J. HOCKING.

*(Continued from page 308.)*

### Comparison of Costs of Melting.

Records are kept in the Department of the results of melting with gaseous fuel for comparison with similar results obtained with coke. These results are available for a period of five complete years ended March 31st, 1916, in the case of gas, and for five calendar years ended December 31st, 1909, in the case of coke. The periods named cover extensive operations. During the five years, 1911-1916, nearly 10,000 tons (over 10 million kilos) of metal were melted and cast into bars for coinage with a total consumption of 121 million cubic feet of gas.

A comparison of the records for the two periods shows an economy in favour of gaseous fuel under each of the following heads.—

(1) Rate of output.
(2) Cost of fuel.
(3) Cost of graphite goods.
(4) Cost of labour.

(1) *Rate of Output.*—Except in the case of gold, crucibles of the same capacity as formerly were used, but the time required for the heats was shortened considerably. The rate of output per furnace in the working day was correspondingly increased, and this increase was especially noticeable in the case of the metals requiring the higher temperatures. In 1909 and in 1913 the largest amounts of cupro-nickel were melted, and, as these metals form the most stringent tests to which the Mint furnaces are subjected, the results of these years are selected to show the comparative rates of out-turn.

| Metal. | Average Melt per Furnace per Working Day of Ten Hours. 1909 (Coke Fuel) | 1913 (Gas Fuel). | Increased Output per Furnace. Cwt. | Per cent. |
|---|---|---|---|---|
| | Cwt. | Cwt. | Cwt. | Per cent. |
| Gold .......... | 5·2 | 9·8 | 4·6 | 88·5 |
| Silver (bars for shillings) .... | 5·7 | 12·8 | 7·1 | 124·5 |
| Bronze......... | 5·2 | 13·4 | 8·2 | 157·7 |
| Cupro-nickel.... | 3·6 | 9·4 | 5·8 | 161·1 |

The same furnaces are used successively for melting silver, bronze, and cupro-nickel. As these alloys have melting points varying more than 200 deg. Cen. between the maximum and minimum, the greatest economy is not effected in all cases. The rates shown would no doubt be further improved if it were possible to allot a suite of furnaces to each metal, and to modify the burners according to the temperature required to melt each class of metal.

(2) *Cost of Fuel.*—The respective costs of coke and gas are well known to vary considerably in different localities. They are also liable to vary in the same locality throughout a given period, although there is a fairly constant relation between the cost of one as compared with the cost of the other. During 1905-9 the price of best foundry coke delivered broken for use at the Mint fluctuated from 35s. as a minimum to 42s. 4d. per ton as a maximum; while during 1911-16 the discount price of gas per 1,000 cubic feet varied only very slightly from 21d., except during nine months of 1915-16, when it was 18·2d. Although the price of gas advanced 12½ per cent during the last five years, the net cost to the Mint remained practically stationary owing to the sliding scale of discounts allowed by the Commercial Gas Company.

On the total expenditure for fuel for the two periods of five years a cash saving of 3½ per cent on the amount consumed per ton melted is shown for 1911-16. The amounts melted and the fuel consumed for the two periods are shown side by side:—

| | 1905-9. | 1911-16. |
|---|---|---|
| Gross amount of metal melted. | 4833 tons | 9899 tons |
| Total consumption of fuel ... | 2677 ,, | 121 million cub. ft. |
| Consumption of fuel per ton melted.............. | 11 cwt. | 12,220 cub. ft. |
| Cost of fuel per ton of metal melted.............. | 21·3s. | 20·58s. |

The above comparison is made on the basis of the gross amount melted. Owing to the general practice of melting two or more metals simultaneously, it was not possible to secure an extended series of records of the fuel consumption for one metal alone. None whatever are available for the coke period. The following rates of consumption for the various metals are approximately true for gas, but, being based upon readings for comparatively short runs, are subject to revision. The approximate specific gravities and temperatures of pouring are added in the table, as these are essential factors in the relative consumption of fuel.

| Metal. | Approx. Specific Gravity. | Approx. Temperature of Pouring. ° C. | Cub. ft. of Gas used per ton Melted. | Cost in Shillings per ton with Gas at 21d. per 1000 cu. ft. |
|---|---|---|---|---|
| Gold ......... | 17·3 | 1150 | 7,000 | 12·25 |
| Silver ........ | 10·35 | 1090 | 12,000 | 21·0 |
| Bronze......... | 8·9 | 1165 | 14,500 | 25·375 |
| Cupro-nickel.... | 8·8 | 1300 | 22,000 | 38·5 |

(3) *Cost of Graphite Goods.*—The crucibles used for both the coke-fired and the gas fired furnaces were of the Morgan Salamander brand, the mixture being modified in the latter case to suit the firing. A considerable extension of life was found when they were used with the gaseous fuel. In addition to minor causes, this was mainly due (*a*) to the greater uniformity of combustion in the furnace, and (*b*) to the absence of abrasion to the soft skin of the heated crucible, which is unavoidable during the periodical poking down of the fuel in the coke furnace.

The total inclusive costs for the two periods are placed side by side, and show that the rate per ton melted has been reduced by about one-third.

| | 1905-9. (*Coke Fuel*). | 1911-16. (*Gas Fuel*). |
|---|---|---|
| Weight of metal melted ........ | 4,833 tons | 9,899 tons. |
| Total cost of crucibles, &c. ..... | £9,625 | £13.295 |
| Cost of crucibles per ton melted | 39·8s. | 26·8s. |
| Rate of reduction in costs ..... | .. | 32·6 per cent. |

The figures for costs shown cover in each case the purchase of muffles, covers, stands and stirrers, as well as of crucibles. In the latter period the total amount includes advances in price due to the war, and also extra costs incurred in the earlier stages before the manufacturers supplied crucibles specially suited for use with gaseous fuel. The mixture now employed gives excellent results. The improvement in the quality of the crucibles is reflected

in the reduction in the rate of cost per ton melted. Comparing the years 1911-12 and 1915-16, the first and last years of the gas period, the drop was from 37s. to 22·7s. per ton melted, and comparing the five years, 1905-9 (using coke), with last year, 1915-16 (using gas), the reduction was from 39·8s. to 22·7s., or about 40 per cent.

The two tables which follow are compiled to show the

COST FOR FIVE YEARS (1905-9) WITH COKE FUEL. (Fuel and Crucibles).

| Period. | Weight of Metal Melted. Gold and Silver. | Bronze and Cupro-nickel. | Total. | Expenditure. Fuel (Coke). | Crucibles, Muffles, &c. | Total. | Cost per Ton (Average). Fuel. | Crucibles. | Total. | Percentage of Total in Bronze and Cupro-nickel. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | £ | £ | £ | £ s. d. | £ s. d. | £ s. d. | Per cent. |
| 1905 | 386 | 131 | 517 | 561 | 1,019 | 1.580 | 1 1 8 | 1 19 5 | 3 1 1 | 25 |
| 1906 | 630 | 297 | 927 | 837 | 1,810 | 2,647 | 0 18 1 | 1 19 1 | 2 17 2 | 32 |
| 1907 | 921 | 293 | 1,214 | 1,227 | 2,208 | 3,435 | 1 0 3 | 1 16 4 | 2 16 7 | 24 |
| 1908 | 476 | 501 | 977 | 1,081 | 2,044 | 3.125 | 1 2 2 | 2 1 10 | 3 4 0 | 51 |
| 1909 | 523 | 675 | 1,198 | 1,455 | 2,544 | 3,999 | 0 4 4 | 2 2 5 | 3 6 9 | 56 |
| | 2,936 | 1,897 | 4,833 | 5,161 | 9,625 | 14,786 | 1 1 4 (Average) | 1 19 10 (Average) | 3 1 2 (Average) | 39 |

COSTS FOR FIVE YEARS (1911-16) WITH GASEOUS FUEL. (Fuel and Crucibles).

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | £ | £ | £ | £ s. d. | £ s. d. | £ s. d. | Per cent. |
| 1911-12 | 1,048 | 445 | 1,493 | 1,639 | 2,767 | 4,406 | 1 2 0 | 1 17 0 | 2 19 0 | 30 |
| 1912-13 | 1,030 | 532 | 1,562 | 1,375 | 2,016 | 3,391 | 0 17 8 | 1 5 10 | 2 3 6 | 34 |
| 1913-14 | 828 | 1,301 | 2,129 | 2,307 | 2,850 | 5,157 | 1 1 8 | 1 6 10 | 2 8 6 | 61 |
| 1914-15 | 1,675 | 673 | 2,348 | 2,291 | 2,971 | 5,262 | 0 19 6 | 1 5 4 | 2 4 10 | 29 |
| 1915 16 | 1,790 | 577 | 2,367 | 2,593 | 2,691 | 5,284 | 1 2 0 | 1 2 8 | 2 4 8 | 24 |
| | 6,371 | 3,528 | 9,899 | 10,205 | 13,295 | 23,500 | 1 0 7 (Average) | 1 6 10 (Average) | 2 7 5 (Average) | 36 |

total costs for fuel and for graphite goods, as well as the average rates of these per ton melted, for the several years of the two periods under review.

*(To be continued.)*

## ADDRESS BY MR. MICHAEL LONGRIDGE TO THE INSTITUTION OF MECHANICAL ENGINEERS.

*(Continued from page 320.)*

In parts of Scotland continuation schools are provided in connection with the industries of the districts, and parents and employers are compelled to send young people to them during working hours between the ages of 14 and 17 years. In England, the difficulty is overcome in some large works by allowing promising boys to spend some of their working hours at technical schools without loss of time or pay. In others, technical instruction is given in the works. Unfortunately, British engineering works are generally too small, and the managers too unwilling, to co-operate with each other to allow such arrangements to become general. Either the age for leaving school will have to be raised or some scheme devised for combining technical instruction (not mere craftsmanship) in the works, but with general instruction in the schools in working hours—unless engineering employers refuse to take lads into the works till they are 15 or 16 years of age. Apprentices entering works from the junior technical schools at 15 or 16 will be better workmen at 21 than those entering at 12 or 14 from the elementary schools.

I think, also, that a clear distinction should be made between technical colleges of university rank on the one hand and senior technical schools, whose entrance standard is lower than university matriculation, on the other. The interests of engineers require two classes of institutions giving technical instruction, each with its definite purpose:—

1. Technical "Colleges."
2. Technical "Schools" (senior and junior).

The Technical "Colleges" should be of university rank, and should be departments or faculties of universities, like the Municipal School of Technology in Manchester, not independent of them, as in Germany. They should provide two courses, one for the scientific advisers and designers, the other for the managers and business organisers.

The reason for making these schools departments of the universities is that the connection would prevent overlapping of teaching, and would ensure that uniformity in examination standards which some of the universities are trying to bring about. By uniformity of examination standards I do not mean uniformity of technological teaching. In this respect some diversity, and some degree of specialisation would be desirable.

The Technical "Schools," both the senior and the junior which are frequently housed with them, should also have two courses, one suitable for men likely to become foremen or supervisors, the other for those likely to remain manual workers. These courses should not be purely technical. The schools would receive their students from the elementary and lower secondary schools. They should remain under the local authorities, so that the technical teaching might be varied in accordance with the local trades.

Another desideratum is co-ordination of the work, especially between the higher secondary schools and what I have called the technical colleges, and between the elementary and lower secondary schools and what I have called the technical schools, so that pupils passing from the one to the other would be properly prepared for the

change. We also need a uniform system of adequate scholarships, to enable the best intellects among the poor to go up the whole educational ladder and mix on equal terms on each rung with those better endowed with this world's goods. The number and values of the scholarships available depend at present too much upon the ideas of the various local authorities.

## Organisation of Engineering.

And now I must pass on to my second point—organisation, or, rather, lack of it. Mechanical engineers are broadly divided into two classes—manufacturers and consultants.

There was a time when the consulting mechanical engineer sent out his own drawings, and the manufacturer had to work to them. Now the engineer sends out his specification, but the manufacturer makes his own drawings and works to them, or offers some standard article complying more or less with the specification of the engineer. To-morrow the engineer will merely describe the work the machinery he requires will have to do, and witness the tests of its performance. Some day he will become a mere inspector, the manufacturer supplying the scheme and the machinery required for its working from his own designs.

But if manufacturers wish to be freed from interference of consulting engineers with their designs and processes, they must give their customers full information about the machinery they tender for. Their specifications are often extremely vague. The specifications of engine builders, for instance, are filled with such phrases as "great strength," "ample bearing surfaces," "best materials," "highest class of workmanship"—none of which convey the slightest meaning to the customer or his engineer. *They* want to know the stresses and pressures per square inch allowed, the materials to be used for the various parts, which surfaces are to be machined, and what tolerances are allowed. It would be better if all engine builders built their own standard engines, as some do now, and refused to alter them, but gave each customer a complete set of blue prints—as very few do now—marked (not necessarily with dimensions), but with stresses, loads, materials, and machining. If the engines were built on a proportional system, one set of prints, though necessarily not to scale, would serve for a whole series. The customer would then see what he was going to buy and the engineer could "manufacture" instead of building each engine to a special design. Thereby much trouble and expense would be avoided.

The objection has been raised that if A sent out his drawings B could copy them. Well, what if he did? A could copy B and both would be gainers by exchanging their ideas. Else why does the Institution of Mechanical Engineers exist?

Except in a few cases, workshop organisation here has not received the attention given to it in America and Germany. There are still shops without definite planning of the progress of the work, without adequate equipment of jigs and gauges, and without standard shapes of tools or a tool room, where men drift about in search of tools and tackle or wait in idleness for drawings or materials, where machinery is obsolete, and light so bad that good work could not be done even if the machinery were up to date.

Such shops will have to go. They cannot compete in price or quality of work with those where what is known as "scientific management," or anything approaching it, prevails; where the progress of every job is planned to the last detail before it is sent into the works; where machinery is so arranged that each piece passes through the whole series of operations to be performed upon it in predetermined order and without pause, and is immediately succeeded by another piece to undergo the same cycle of operations; where labourers and tackle for fixing the work in the machines are ready the moment they are wanted; where drawings, gauges, tools properly ground to standard shapes come with the work; where cleanliness, light, and comfort reign, and where endeavour is made to get the workman to regard his work more as a problem to be solved than as a task to be got through.

And if the industry is insufficiently organised in machinery and shop management, it is still more so in the equally important business of obtaining orders to keep the shops at work. There are no central selling agencies like that of the great thread "Combine." Each firm has its own agents. Some kind of combination or co-operation among engineering firms, especially the smaller firms, seems very desirable, if not indeed essential.

Combinations have been arranged in other trades. The Fine Spinners' and Doublers' Association, Associated Portland Cement Ltd., Wallpaper Manufacturer Ltd., United Alkali Ltd., the North British Locomotive Co., are examples. In Germany, I understand, the dye trade, and all the trades ancillary thereto, have just been combined into one vast concern, with a capital of 800,000,000 marks. The great and powerful combinations in the steel trade in America and Germany cannot be ignored. The industrial world does not stand still. Similar combinations among engineers will have to be seriously considered.

Such associations as the Federation of British Industries and the British Engineering Association (the B.E.A.), with which is now amalgamated the Council for the Organisation of British Engineering Industries, the British Electrical and Allied Manufacturers' Association, etc., might serve as the components of a practical and effective scheme for the organisation of the British engineering industry.

At the one end of the chain there might be the individual employer responsible to the district executive of the British Engineering Association for the management of his own works, the corresponding trade union authority being the shop stewards or the men's shop committee.

The next link would be the district executive of the British Engineering Association, with which might be amalgamated the district committee of the existing Engineering Trades Employers' Federation. This district executive would be charged with the oversight of the district employers, works, and trade. In co-operation with the district officers of the trade unions they would arrange rates of wages and piece-work, terms of co-partnery, the number of apprentices for whom places could be found, and the means of continuing their education. The district executive would receive reports from employers as to the state of their order books, their difficulties with labour, supply of materials, and transport; also as to experiments and research required to overcome local manufacturing difficulties, and would report to the Executive Council of the B.E.A.—*i.e.*, the executive council of the entire engineering industry.

The next link—the supreme body in the engineering trade—might be the executive council of the British Engineering Association. With it might be amalga-

mated the existing Engineering Trades Employers' Federation. Its proposed activities would include transport, intelligence, production, patents, publicity, finance, education, research and legislation in the broadest sense. The council would act through standing committees.

Last of all would come the federation of (all) British industries and the federation of trade unions, if that body be brought to birth. These would deal directly with a Minister of Industry and Commerce. The chain would then stand thus:—

| | | |
|---|---|---|
| The Manufacturer. | = | The Shop Stewards. |
| The District Executive of the B.E.A. | = | The District Officers of the Engineering Trades Unions. |
| The supreme Executive Council of the B.E.A. | = | The Executives of the Engineering Trade Unions. |
| The Federation of (all) British Industries. | = | The Federation of Trade Unions. |

The Ministry of Industry and Commerce.

As yet there is no Minister of Industry and Commerce, but there is a Minister of Labour. Labour is a very essential element in industry. Both have the same interests. Let us not have two Government departments to squabble with each other and accentuate the difficulties which we hope to smooth away. Let the Ministry of Labour absorb all interests and become the Minister of Industry and Commerce, acting for the interests of employers and employed alike.

***(To be continued.)***

## SETTING STEAM BOILERS:

### WITH PARTICULAR REFERENCE TO LANCASHIRE AND CORNISH BOILERS.

By Edward Ingham.

The power user who purchases a steam boiler nowadays usually realises how important it is that his boiler should be of the very best design and construction, and the question of first cost is considered of secondary importance.

Whilst, however, most steam users will not hesitate to procure the best boiler that money can buy, it is a fact that many do not get the most out of their boilers, both as regards efficiency and longevity, because they fail to appreciate the importance of setting the boilers in the most approved manner.

If a boiler is to have a long working life, and to work economically, it is absolutely necessary that the question of setting should receive careful consideration, and in what follows we shall explain in what respects the setting may be good or otherwise.

The form of the setting required for any particular boiler is, of course, governed by the type of the boiler.

Boilers of the vertical type, including ordinary cross-tube, Cochran and other types, are generally supposed not to require any setting whatever, all that is commonly said to be necessary being to place them on a hard level surface. The same may be said with regard to boilers of the locomotive type, semi-portables, and such like. In the case of water-tube boilers, the setting consists principally of an external casing, the main object of which is to confine the heat of the furnace gases and provide furnace space.

It is in connection with boilers of the large cylindrical type, such as the Lancashire, Yorkshire, Cornish, and Davey Paxman that really expensive brickwork settings are required, because with such boilers it is necessary to make the furnace gases travel two or three times along the length of the boiler, and special brickwork flues must thus be provided in order that this may be done. Hence, in this article, we shall confine our attention principally to Lancashire and Cornish boilers.

It has already been pointed out that boilers of the vertical type are generally supposed not to require any setting whatever, all that is commonly said to be required being to place them on a hard level surface. It is, however, necessary to explain that in many cases some preparation should be made for setting the boiler. The fact should not be overlooked that the fireboxes of vertical boilers are liable to suffer severely from external wasting, owing to the presence of moisture or damp in contact with the plates when the boilers are not working. It is therefore very desirable that the boiler should be so fixed that access to the firebox for the purpose of examination may be readily obtained. In the case of large boilers the firehole will usually be sufficiently

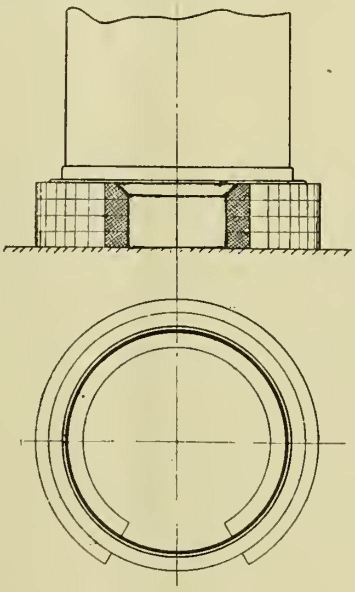


Fig. 1.

large to enable a man to pass through into the firebox, but in other cases access to the firebox cannot be gained in this way. In modern boilers, it is common to extend the shell plates some distance below the foundation seam, leaving a rectangular opening in the extension sufficiently large to enable a man to pass through. With this arrangement not only is the firebox rendered accessible, but should there be any tendency for external corrosion of the lower parts of the boiler to take place, it will only be the extension that is affected, and not the boiler itself.

Where such provision is not made the firebox must be made accessible in some other way, and this may be done by mounting the boiler on a circular brick wall about one foot high, the wall being left open at one part, *i.e.*, directly underneath the firedoor. (See Fig. 1.)

An objection to this arrangement is that brickwork, owing to its porous nature, is liable to become damp, in which case serious wasting about the foundation seam of the boiler may be set up.

Another way in which the firebox may be made accessible is by digging a rectangular pit underneath the boiler, but this again is not such a satisfactory arrangement as that of extending the shell plates and providing an opening in the extension.

In some cases, with the object of guarding against wast-

ing of the lower parts of the boiler through contact with the damp ground, vertical boilers are placed in circular cast iron bases of channel section, but these are objectionable because they form a receptacle for dirt and damp ashes, which, resting against the lower portions of the boiler, are very liable to set up wasting at these parts.

Boilers of the locomotive type used as stationary boilers are usually fixed on a cast-iron stool at the chimney end and on a frame of box section at the firebox end. As in the case of vertical boilers, it is generally advisable to provide a shallow pit under the frame which will give access to the firebox and facilitate cleaning, unless the draught door opening in the frame is large enough to allow a man to pass through.

With regard to water-tube boilers, a brickwork setting, as pointed out, is provided principally with the object of confining the heat of the furnace gases and providing furnace space. The boilers are mostly supported by means of brackets and beams, supported by steel columns, so that the weight of the structure has not to be borne by the brickwork, as in the case of large cylindrical boilers.

The brickwork setting consists of an internal lining of firebrick and an outer wall of ordinary brick, which is, as a rule, painted over with one or other of the various heat-resisting paints now on the market. It is particularly important that the casing should be maintained in good condition, as otherwise serious loss will occur through leakage of cold air into the setting. The extent of the loss which may occur through leakage of cold air through defective brickwork, bad joints, cracks, etc., is seldom realised by power users, but that it is considerable there can be no question. Radiation losses may also be very serious unless the casing be such as will effectively prevent the heat from radiating away.

With the object of minimising, as far as possible, the losses referred to, the settings of water-tube boilers have, in some instances, been provided with a sheet-steel casing built just outside the brick casing. By means of such casing, the setting is maintained in an air-tight condition, so that even should the brickwork become defective, as it is always liable to, particularly when the boilers are subject to sudden variations of load, as at electric generating stations, cold air cannot leak into the setting. It seems more than likely that in the near future the practice of using steel casings in connection with the settings of water-tube boilers will meet with general favour.

We now pass on to deal with the setting of Lancashire and Cornish boilers, and, at the outset, we would point out that so far as boilers of this class are concerned, there are quite a number of factors which require careful consideration if the best results are to be obtained.

The first consideration is the selection of a suitable site. It is of the first importance that the situation should be a dry one, as otherwise serious deterioration is liable to result from general external wasting of the boiler plates. There is nothing more liable to cause external corrosion of boilers than damp brickwork. Brickwork is more or less porous and readily absorbs moisture, so that if the situation is a damp one the whole of the setting may become damp and give rise to extensive wasting of the plates.

Low situations, such as, for example, those below the level of a river or a canal, where the boiler will be exposed to damp or surface moisture, should therefore, whenever possible, be avoided. The foundation should always be above the level of the drains, so that there will be no difficulty in running off any water which may drain into the setting.

The best material on which to build the setting is concrete, and in most modern settings a good concrete bed is provided. The thickness of the bed required depends upon circumstances, such as the nature of the soil, the weight and size of the boiler, etc. For clay, or ordinary firm earth, a usual thickness is 12 in. for large boilers.

The concrete should be of good quality and impervious to moisture, so that there will be no tendency for moisture from the ground below rising up into the setting.

If there is any likelihood of moisture passing through the side walls of the setting, it is a good plan to carry the concrete bed at the sides up to the outside ground level.

When the ground is very damp a layer of flags may with advantage be placed underneath the concrete bed with the object of preventing the damp from striking up into the setting, more particularly when the concrete is of a porous character.

Having fixed upon a suitable site and foundation, the next thing to be considered is the building of the external flues. These should always be built of ample size, *i.e.*, quite large enough to afford reasonable facilities for cleaning and inspection. Cramped and inaccessible flues are particularly objectionable, because not only do they interfere with satisfactory cleaning or inspection, but they may, under certain conditions, impair the draught, and without a good draught the fuel cannot be burnt to the best advantage.

It is well to remember that no part of the flues should be made of less cross-sectional area than that of the throat of the chimney, or, say, one-eighth the area of the firegrate. In order than a man may pass freely through the side flues the width of these at the narrowest part, *i.e.*, the part corresponding to the mid-height of the boiler, should never be less than nine inches.

Generally speaking, a width of 12 in. at the part referred to will give the most satisfactory results, and this applies both to Lancashire and Cornish boilers. Because a Cornish boiler is smaller than a Lancashire, it does not follow that the side flues need not be as large as those for the Lancashire boiler, as is sometimes supposed.

*(To be continued.)*

## TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.

At a recent meeting of the Technical Committee of the Motor Industries, which has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders, a number of questions of interest to the industry were considered.

Amongst these was the desirability of establishing a Bureau of Technology, and a deputation was appointed to consult the National Advisory Council on the matter.

Another matter dealt with was the question of research on laminated road springs, and it was decided to collect all available information on this subject as a preliminary step.

The question of the supply of small steel castings to the industry after the war also occupied the attention of the Committee, and it was decided that the Iron and Steel Institute should be communicated with on the matter.

It was resolved that the Bill on Decimal Coinage which has been drafted by the Association of Chambers of Commerce should be supported.

A number of suggestions have been received as to the various ways in which the Committee could be of assistance in the direction of research, and these will be dealt with at a further meeting to be held shortly.

# Trade Items, Notes, &c.

Foundation Pressures.—The coal plant of the New York Steam Company at Water Street, New York, stands on a concrete slab-and-girder mat over wet sand. It is surrounded by a ring of interlocking sheet-steel piling, and the pressure on the sand is 5,004 tons per square foot. A trial installation loaded to 6 tons settled 0·061 ft. in 237 hours. The details are given in *Engineering News* of March 22nd.

Graphite in Madagascar.—The production of graphite in the island of Madagascar in 1915 amounted to 15,000 tons, compared with 8,000 tons in 1914, 6,319 tons in 1913, and 1,500 tons in 1911. Because of the large demand for this mineral in France and England the local Government has called upon the producers throughout the island to increase their output, and it is believed (says the *South African Mining Journal*) that the production for 1916 will greatly exceed 20,000 tons.

The Association of Engineering and Shipbuilding Draughtsmen.—The first meeting of this association to be held in Huddersfield took place in the Technical College on May 5th, 1917, and representatives attended from Halifax, Brighouse, Sowerby Bridge, Elland, and Huddersfield. Speakers from Manchester and Leeds addressed the meeting, and it was ultimately decided to elect a sub-committee which would further the objects of the association in the above district. Arrangements are being made to hold a meeting in Halifax.

By-product Coke and Coking Operations.—From an instructive article by Messrs. C. J. Ramsburg and F. W. Sperr, of the H. Koppers Company, Pittsburg, published in the Journal of the Franklin Institute of April, 1917, we see that by January, 1915, there were 6,438 by-product recovery ovens in the United States and Canada, of an aggregate capacity to carbonise about 24,000,000 tons of coal and to produce nearly 19,000,000 tons of coke therefrom per annum. Although 500 of these ovens have been discarded, 9,900 ovens are expected to be working by 1918. The increase is ascribed not so much to the inflated war prices of by-products as to the general financial conditions favouring development of plant.

Export Standardisation Rules.—"The recent announcement in the technical press to the effect that the Council of the British Electrical and Allied Manufacturers' Association has issued a set of British export standardisation rules for electrical machinery having, unfortunately, given rise to misapprehension, I am desired," says the secretary of the Association, "to state that these rules are in no way intended to replace the British standardisation rules for electrical machinery, which are issued by the Engineering Standards Committee to cover British-made plant for home and export trade, and in the drafting of which the Association is closely and cordially co-operating."

Turbine Troubles at Shanghai.—According to the annual report of the electrical engineer to the Shanghai Municipal Council (Mr. T. H. U. Aldridge), the disastrous experiences with two A.E.G. turbines of 2,000 kw. capacity recorded in last year's report have been supplemented by the failure of one of 5,000 kw. units. The plant has proved so unsatisfactory that it was considered necessary to include in contracts with the more important consumers a clause authorising a limitation of the supply should the necessity arise. Advantage had to be taken of this clause on several occasions during the year covered by the report. The new machinery on order is being obtained from Great Britain and from the United States, and will consist of one 10,000 kw. unit built by the General Electric Company, another of the same size by Messrs. C. A. Parsons and Co., and a 5,000-kw. plant supplied by Messrs. Fraser and Chalmers.

A New American Alloy.—An alloy containing 92 per cent to 97 per cent of aluminium, and offered as a metal of strength and lightness, and non-corrosive suitable for use in the manufacture of automobiles, aircraft, military equipment, hardware, etc., has been put on the market in America. It is the discovery of M. De Montby, a Frenchman, and is being supplied, it is said, to the French Government for the manufacture of helmets. It is silver-white, has a specific gravity of 2·82, and a melting point of 1,382 deg. Fah. Its tensile strength in castings is given as 30,000 lbs. per square inch, and in rods and sheets up to 64,000 lbs.; heat treated, its tensile strength is given as over 70,000 lbs. per square inch. It is claimed that it may be sand cast, die cast with or without pressure, hot and cold forged, annealed, drawn, rolled, stamped, hardened by temper, polished, electro-plated, and soldered. It withstands the action of all acids except hydrochloric.

A Non-corrosive Alloy.—A white, non-corrosive, and malleable alloy of iron, nickel, and copper, patented by Clamer, may be rolled, drawn, or cast in sand. It has a whitish colour, and can be made in the following range of percentages: Iron, 30 per cent to 70 per cent; nickel, 25 per cent to 50 per cent; copper, 5 per cent to 20 per cent. Pure copper and iron will alloy in all proportions, and form a homogeneous mixture; but when carbon is present, as it is in steel or cast iron, the two metals do not alloy well, and hard nodules separate, depending upon the quantity of carbon. If, however, carbon is present, then the tensile strength of the alloy is increased, but the quantity should not exceed 0·2 per cent in order to have the best conditions. A typical mixture is: Iron, 65 per cent; nickel, 25 per cent; copper, 10 per cent; carbon, 0·2 per cent. The physical properties of this were stated by Clamer to be: Tensile strength, 96,100 lbs. per square inch; elastic limit, 51,750 lbs. per square inch; elongation in 2 in., 42 per cent; reduction in area, 53·7 per cent. To make the alloy, the metals are melted so that carbon is kept low, and a small amount of manganese or magnesium added for deoxidising purposes.

Purchase of Charabancs by the Government.—The Commercial Motor Users' Association has for some time past been in negotiation with the proper Government authorities as to the possibility of sale to the Government of motor charabancs which have been lying idle since the Order in Council of August last, prohibiting the use of motor spirit in charabancs. Whilst no guarantee can be given that sales will result, the Association is authorised to collect the following information in respect of each vehicle in an official list: (*a*) Horse power, type, make, and date of manufacture of chassis; (*b*) total mileage to date and general condition of vehicle; (*c*) class of body and seating accommodation; (*d*) where chassis can be inspected. The Association is also authorised to state that in cases where motor charabancs chassis have been taken by the military authorities and the charabancs bodies left on the owner's hands particulars of such stocks of bodies will also be considered, with a view either to (*a*) purchase or (*b*) compensation. Owners of charabancs who are desirous of availing themselves of the opportunity are requested to communicate with Mr. Frederick G. Bristow, F.C.I.S., secretary, Commercial Motor Users' Association, 83 Pall Mall, S.W. 1.

A Gas Engineer's Views on Electricity.—In the course of his presidential address at the annual meeting of the Scottish Gas Managers Association, in Glasgow, Mr. Charles Fairweather (Kilmarnock), dealt with a variety of topics, including the development in electricity supply. This, he said, had brought the gas industry from what was practically a monopoly down to the level of a competitor, and who would say that the change was not for the good of the industry? A monopoly at all times tended to conservatism, and that might gradually merge into a state of repose inducing a peace which did not willingly seek for struggle. Immediately the development of electricity supply became an accomplished fact, readjustment of gas supply methods was the result, and to-day in all large cities and industrial communities the two industries progressed side by side. There was no question that each had its sphere, and that each had its limitations, and this was amply proved by the fact that within the same community both businesses might be simultaneously developed and increased. In thickly-populated industrial districts central stations for electricity supply would be laid down, and current distributed to the surrounding areas at the lowest possible cost for all purposes, and if gas supply was to maintain its place, this was the form of competition which it would be called upon to face. A factor which handicapped, to a certain extent, the gas business, was that small works already existed, and were scattered about, each undertaking a small radius of supply, whereas, electricity being a younger industry, stations had yet to be put down, and the position of these stations could be so chosen that a large district could be taken in. At present it was the case that, in large districts with a number of small gas undertakings, these were being absorbed, and this had been largely brought about by high-pressure distribution of gas, making it possible to stretch out long lines of mains and supply from a central works.

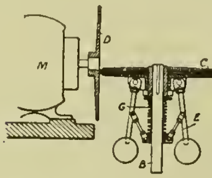
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

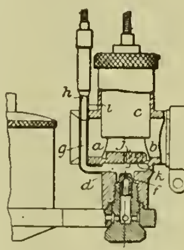
## ABSTRACTS OF SPECIFICATIONS.

### DRIVING DYNAMOS.

103,835.—W. F. W. RHODES, 8, Toller Drive, and J. FIRTH, 42A, Greaves Street, Little Horton, both in Bradford, Yorkshire.—May 22nd, 1916.—A dynamo M is driven at a constant speed from a variable-speed shaft B on trains, motor-vehicles, etc., by the use of friction discs or plates, C, D; the disc C is moved axially up and down the shaft B by means of a centrifugal governor E controlled by a spring G or by weights. The convolutions of the spring may be wound in conical form or at varying distances apart, or the spring may be of wire or varying section, or a series of springs placed one inside the other or of differing lengths may be used. A solenoid excited by the dynamo current may assist in controlling the action of the governor and sliding plate.



Patent 103,835.



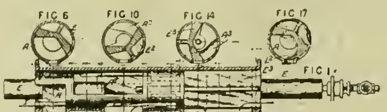
Patent 103,847.

### INTERNAL-COMBUSTION ENGINES.

103,847.—E. HUTCHINSON, Outram Street, Sutton-in-Ashfield, Nottinghamshire.—Feb. 8th, 1916.—In carburettors in which fuel is fed through a submerged nozzle into a chamber in which it may accumulate, and which chamber communicates both with the atmosphere and with a straight-through passage of the carburettor, the communication with the straight-through passage is in line with a manually-actuated piston throttle valve, which is moved across the passage. Fuel from the float chamber passes through a nozzle *f* into the chamber *d*, which is below the fuel level, is open to the atmosphere through apertures *i* controlled by a valve *h*, and communicates with the passage *a*, *b* through openings *j*, *k* in line with the throttle valve *c*. The openings *k* diverge from the central opening *j* towards the mixture outlet and may be replaced by slots. Air through the conduit *g* passes over the nozzle *f* before reaching the openings *j*, *k*. Two valves may replace the valve *c*. According to the Provisional Specification, two or more chambers may be used in succession, the whole of the air may pass through the chambers, and the nozzle *f* may be pointed and project into the chamber *d*

### FLUID-PRESSURE ENGINES.

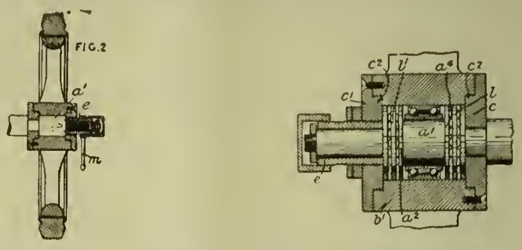
103,862.—T. E. HALLIDAY, Glenesk, Bishopstoke, Hampshire.—Feb. 15th, 1916.—Fluid pressure is distributed by a rotary valve having peripheral admission and exhaust ports connected by longitudinal passages which may act as receivers and may be supplied with main-pressure fluid for starting. In the valve for a single-acting triple-expansion engine, fluid is supplied to the high-pressure cylinder by the port A, and passes from there through port E, a passage in the valve, and port A2 to the intermediate-pressure



cylinder. Similarly, the fluid passes from the intermediate-pressure cylinder through ports E2, A3 to the low-pressure cylinder, from which it is exhausted through port E3. The high-pressure element may be provided with additional lap L2 to increase expansion. Reversal is effected by rotating the valve relatively to its gear. The auxiliary fluid for starting may be controlled by a hand-valve. Double-acting engines provided with similar rotary valves, and groups of cylinders arranged V-fashion or at right-angles, are described.

### SECURING WHEELS ON SHAFTS, ETC.

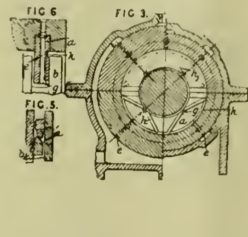
103,866.—W. T. J. HIGGITT, 104, Ormside Street, Old Kent Road, London.—Feb. 16th, 1916.—Relates to means for securing wheels, etc., on axles, shafts, etc., of the type in which memebers secured to the wheel act on the ends of an enlargement of the axle so as to prevent relative longitudinal movement. In the form shown in Fig. 1, the flanged members *c*, *c*1 screw into the hub *b*1 to provide the adjustment, and they act, through ball bearings *l*, *l*1, on the shoulders *a*4, *a*2 of an enlargement *a*1 on the axle. The parts may be tightened by a screwed sleeve *e*. In the form shown in Fig. 2, the flanged members act on the ends of a sleeve *a*1 slidably mounted on the axle and capable of being frictionally



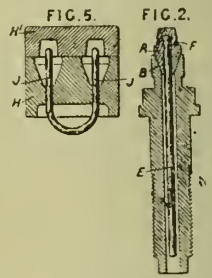
locked in contact with the flanged member *c*2 by screwing up the sleeve *e*. The sleeve *e* may be rotated through a Bowden wire acting on the lever *m*.

### LUBRICATING.

103,867.—SIR C. A. PARSONS, S. S. COOK, and L. M. DOUGLAS, Turbinia Works, Wallsend-on-Tyne, Northumberland.—Feb. 16th, 1916.—In a thrust bearing for shafts consisting of a number of fixed and rotating collars *a*, *b*, lubricant is admitted through radial passages *e* to recesses *g* near the roots of the rotating collars *b*, and passes outwardly through inclined grooves *h* in the working faces of the stationary collars *a*, the outward flow being accelerated by the rotation of the collars *b*. The grooves *h* are inclined in both directions and may terminate in a circular channel *k*, which allows the lubricant to escape freely and prevents the formation of ridges in the face of the collar *a* due to wear. If the collars *a* are divided for taking thrusts in two directions, the adjacent ends are chamfered as shown in Fig. 5, to prevent the lubricant from being swept off the face of the rotating collar.



Patent 103,867.



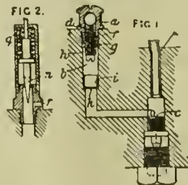
Patent 103,869.

### VALVES.

103,869.—T. SLOPER, Southgate, Devizes, Wiltshire.—Feb. 16th, 1916.—In a rubber valve head of the ordinary type, such as A, moulded and vulcanised prior to the insertion of the wire spindle E, the socket in the valve head is extended up into a reduced upper part beyond the closure part B, and the head is secured on the valve spindle E by a binding, such as a split ring F, which grips it at a point below the enlarged end of the wire spindle. By this arrangement, distortion of the operative face of the valve is avoided. The valve heads are formed in a two-part mould H, H1 provided with orifices to receive pins J to constitute cores for the sockets. The pins are a close fit in the orifices and are looped together in pairs, as shown.

### INTERNAL-COMBUSTION ENGINES.

103,872.—BROWN AND BARLOW, Westwood Road, Witton, and C. BROWN, 53, Bayswater Road, Birchfield, both in Birmingham.—Feb. 16th, 1916.—In carburettors wherein the suction on the fuel jet is varied by controlling the air inlet to a chamber above the jet, the control means are of such a nature that the flow of air to the chamber cannot be less than a predetermined minimum or greater than a predetermined maximum value. The conduit *b*, Fig. 1, which supplies air to the chamber above the jet *c* is provided, at its inlet end, with a nipple *a*, the passage *d* through which is adjustable by a screwed plug *f*. This plug has a slot *g* for the greater portion of its length and an axial hole *h* for



the remainder, and when screwed up so as to cover the slot *g*, air is supplied through the hole *h* only, and this is the predetermined minimum. When unscrewed, air passes through the slot *g* as well, and the flow is increased, but the predetermined maximum is determined by an aperture *k* in a ferrule or cup *i*. In the modification shown in Fig. 2, applicable to aeronautical engines, the air is manually controlled by a needle valve *n*, the maximum opening being determined by a shoulder *q* on the stem; the

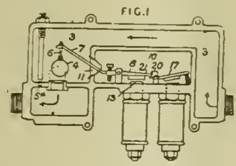
valve may be closed entirely, in which case the minimum supply will take place through the aperture $r$. In a further modification the inlet aperture is controlled by the bevelled edge of a rotatable sleeve, the motion of which is limited by stops. In another modification, a sliding sleeve is employed which, in the case of aeronautical engines, may be actuated by a barometric device.

**FUEL.**

103,873.—A. ROLLASON, 13, Lime Grove, Long Eaton, Derbyshire.—Feb. 17th, 1916.—To improve the combustion of coal, it is mixed with 1-2 per cent of finely ground calcium carbonate or magnesium carbonate.

**VALVES.**

103,879.—E. C. ST. JOHN, Queen Anne's Chambers, Westminster.—Feb. 21st, 1916.—Relates to electrically-actuated valves of the kind comprising a valve member 4 carried by one armature lever 7, 8 which is controlled by a second spring-controlled armature 17 acting as a catch 20, 21 to retain the first armature in, say, the



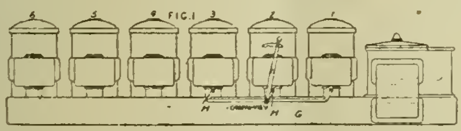
open position of the valve. In such apparatus, the armature chamber 10 is isolated from the gas passage 3, and the opening 11 for the armature lever 7 is closed by a flexible diaphragm of kid, as shown. The cores 13 alone of the electro-magnets enter the armature chamber 10. The valve member comprises a ball 4 suspended by a link or chain 6 from the armature lever 7, 8. A by-pass 5* is controlled by a needle valve, as shown.

**FUEL.**

103,893.—A. ROLLASON, 13, Lime Grove, Long Eaton, Derbyshire.—March 3rd, 1916.—In order to render the combustion of coke more complete, it is mixed with 1·3 per cent of finely-ground calcium carbonate or magnesium carbonate.

**INTERNAL-COMBUSTION ENGINES.**

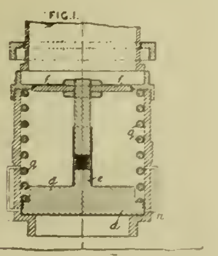
103,896.—SCOTTS' SHIPBUILDING AND ENGINEERING CO. and J. RICHARDSON, Greenock.—March 15th, 1916.—In multicylinder two-stroke-cycle engines which ignite their charges wholly or in part by the heat of compression, and from which the combustion gases are expelled by scavenging-air, to ensure that at starting and during slow running the compression shall produce the ignition temperature the supply of scavenging-air to some of the cylinders is increased by cutting off the supply to the remaining



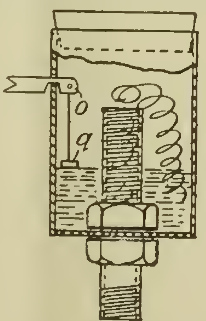
cylinders. In the engine shown in Fig. 1, scavenging-air, which is also used for the formation of the working charge, is normally supplied from a common compressor through a pipe G to the whole of the cylinders. At starting or during slow running, the supply to the cylinders 1, 2, 3 is cut off by closing throttle valves controlled by arms H, the whole of the air supply being then available for use in the remaining cylinders 4, 5, 6.

**INTERNAL-COMBUSTION ENGINES.**

103,910.—W. SAMUEL, Fronwerdd, Cwmllynfell, Swansea Valley, and W. A. JONES, 75, Rhyddings Park Road, Swansea.—April 19th, 1916.—An injector worked by the pressure of the explosion is screwed into the head of the cylinder. The explosion acts upon the underside of the piston $d$, which carries, through a resilient



Patent 103,910.



Patent 103,913.

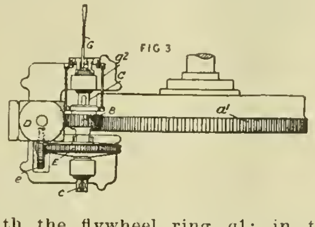
rod, $e$, a water-inlet valve $f$. On the piston rising against the spring $q$, the valve $f$ is first closed, and then lateral ports $n$ are uncovered, through which the water escapes into the engine cylinder. According to the Provisional Specification, the water may enter the injector through a hollow piston-rod and escape through a port in the piston controlled by a ball valve.

**LUBRICATORS.**

103,913.—L. W. WILLIAMS, Railway Appliances Works, Darlington. April 19th, 1916.—An oil-can is provided with a level-indicator consisting of a float $q$ connected to a signal arm $o$ or to a weight suspended outside the cup. The oil is delivered from the cup by a siphon wick.

**ENGINE-TURNING GEAR.**

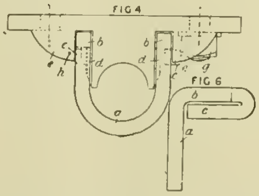
103,920.—VICKERS LTD., Vickers House, Broadway, Westminster, and J. MCKECHNIE and W. F. RABBIDGE, Naval Construction Works, Barrow-in-Furness, Lancashire.—May 5th, 1916.—In hand and power turning gear for use with submarine engines, etc., a spur wheel B on a shaft C may be slid by a lever G and links $g2$ into three positions. In the first position, the wheel is clutched to a worm and wheel gear $e$, E, etc., driven by a motor D, and



gears with the flywheel ring $a1$; in the second position, the clutch is disengaged and the shaft C driven by ratchet gearing from a handle placed on the squared end $c$ of the shaft C; and in the third position, the wheel B is disengaged from the ring $a1$. The pawl $f$, Fig. 4, may be held in the neutral position or tilted for either direction of drive, by a spring-pressed plunger $f2$ sliding in the handle F.

**BEARINGS.**

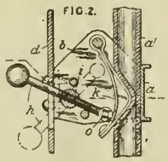
103,922.—G. H. GROVES, Gresford Collieries, Wrexham, and A. GROVES, 91, Barnsley Road, Goldthorpe, Rotherham.—May 11th, 1916.—A pedestal bearing for pit tubs is provided with an axle



guard comprising a U-shaped part $a$ with arms $b$ bent at right angles, and extensions $c$ of reduced thickness bent back under the arms $b$. The guard is pushed axially into slots in the pedestal with the arms $b$ resting on projections $d$, and the parts $c$ spring or are bent out sideways to engage behind projections $e$ to lock the guard in position. The parts $c$ also bear against the sides of, and lock, the nuts $g$ by which the pedestal is secured to the vehicle, or the nuts may be locked by cotters passed through holes $h$.

**VALVES, ETC.**

103,930.—T. JONES, 2, Morley Road, Lewisham, London.—May 24th, 1916.—A pinch cock for the petrol supply of aeroplanes, motor-cars, etc., comprises a frame or stirrup $a$ through which the flexible supply tube $a1$ passes, and a pendulous pinching-lever pivoted between the side plates $b$. A plate $d$ is provided for mounting the cock in any convenient position, and through

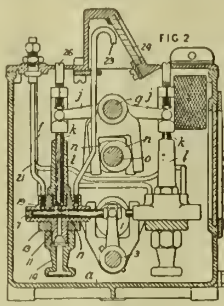


this plate projects the handle $h$ of the operating-lever, the inner end having rollers $o$ operating on the cam-shaped back $k$ of the pinching-lever. The lever $h$ is adjustable in the pivot shaft $i$ by screwing. Two or more cocks with independent operating levers may be mounted with a common face-plate $d$. The cock may be operated by a push-and-pull rod acting in conjunction with toggle levers on the pendulous lever.

**LUBRICATORS.**

103,945.—H. KENT-NORRIS, Ashdown, Pyle Hill, Newbury.—July 15th, 1916.—In a lubricator having a number of cam-operated pumps and reciprocating slide valves, the valve-actuating shaft is driven intermittently by Geneva-stop mechanism. A number of pumps $l$ arranged in a reservoir $a$ in two rows force oil alternately to delivery pipes 21 and to observation nozzles 23 placed behind a sight-glass 24. Slide valves 7 have suction ports 17 in the central position and longitudinal delivery passages 19. A rock-shaft 3 operating the valves is operated by a cam 1 on a short shaft, which is rotated from the main cam-shaft $o$ by Geneva-stop mechanism; by this means, the valves are held stationary during the strokes of the pump plungers $k$. The plungers are prevented from operating during movement of the valves by

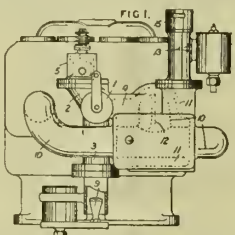
lost motion between the operating arms $j$ and adjustable screws 26, which are also used to vary the strokes. The arms $j$ are loose on the shaft $g$ and are operated by cams $n$. The various shafts are supported by brackets secured to the cover within the reservoir $a$, and the pumps are supported by cross-pieces 13 connecting the brackets $f$. Spigots 11 on the pumps engage with screwed



suction nozzles 14 below the cross-pieces 13. The shaft $o$ is connected by a detachable coupling with a driving-shaft projecting through the wall of the casing $a$. In a modification, the pumps are arranged on one side only of the shafts $g$, $o$, and the observation nozzles 23 are dispensed with.

### INTERNAL-COMBUSTION ENGINES.

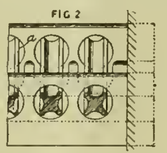
103,942.—F. L. MACLAREN, H. B. MACLAREN, and MACLAREN BROS., Sandpoint Yard, Dumbarton.—June 27th, 1916.—A ported rotatable tubular valve 1 is employed to place the induction pipe in communication with a supplementary air passage 2 and with passages 3 or 4 for a petrol or heated paraffin mixture respectively. Petrol is supplied through the nozzle 9, and paraffin from



the nozzle 13 is allowed to drop on to the hot exhaust pipe 10, around which the mixture is caused to circulate by a jacket 11 having a partition 12. The supplementary air is controlled initially by a suction-actuated valve 5, and the primary air for the nozzle 13 is admitted through a cap 15.

### FURNACES.

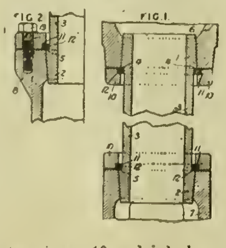
103,965.—G. H. TIMMIS, Lye, and W. D. JONES, River Stour Works, Lye, Stourbridge.—Sept. 28th, 1916.—An inclined grate is formed of bars $a$ grooved or fluted on all their faces and mounted so that



they can be turned separately by means of a key to present fresh surfaces to the fuel. The bars are preferably four-sided as shown, and slope downwards from the front of the furnace, and water for cooling is run down the grooves.

### PIPE JOINTS.

104,078.—H. SLADE and F. W. GREEN, GREEN AND SON, Wakefield April 20th, 1916.—The tapering ends 1, 2 of the tubes 3, Fig. 1, of a fuel-economiser for steam boilers, etc., are secured to the top and bottom headers 6, 7 by forming each header with a number of holed bosses 8, Fig. 2, preferably four, adapted to receive bolts



13 for drawing up plate rings 10, which have an internal diameter equal to, or greater than, the maximum external diameter of the tube 3, and are recessed at 11 to receive split metal rings 12 arranged to bear against the faces of the headers and against shoulders 4, 5 on the tube 3.

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# EDITORIAL.

## UNREST IN ENGINEERING.

### The Food Problem.

Governments are notoriously slow in getting at the roots of the many evils which crop up during great wars, and the present Government is little better than its predecessors, although there has been introduced to its councils a leven of business men. Notwithstanding this leven of commercial ability, the abuses which require an immediate remedy seem to grow instead of to become less. For instance, there is the great and universal question of food supply and prices, which seems to be as far off settlement as ever. Meanwhile the prices are still rising, and the profiteer is making his pile. The workers, who form the largest bulk of the population of this country, naturally feel it worst, in spite of the fact that wages have been most heavily increased in every trade. As, however, everyone knows, it is not the question of mere increase in amount, but the purchasing value, which determines whether the rise is beneficial or not. This is the most elementary of economics, but it is what the wives of the workers have to consider in their weekly purchases.

### Other Factors.

The food problem is undoubtedly one of the factors which contributes to the unrest in engineering matters, but it is by no means the sole factor. Others are the effect of dilution of labour, both in Government and private work, and particularly in the latter; the feeling that their unions are somehow being undermined by the introduction of women's labour and the use of male unskilled labour in doing what has hitherto been considered work for the fully-qualified skilled man; the question of wages to the unskilled and semi-skilled workers engaged on work hitherto done by skilled workers. In addition to these factors, there are hundreds of little grievances, each very trifling in itself, which in their collective capacity bulge largely on the men's horizon as a great grievance. To settle the food problem by bringing prices into reasonable compass, as they can be if the Government is in earnest, would go a long way to securing a reasonable settlement of many other matters, as by its deeds in this matter alone the Government will be judged as to the character of its intentions and its powers to keep to the promises already made to the engineers as the bargain for the unions' foregoing a great many of the privileges which they have won by costly efforts in the past in order that the output of munitions should be increased.

### The Question of Agreements.

This question of promises is a thorny one, but no one with any claims to honesty of dealing would for a moment suggest that the promises should be broken. We do not for a moment suggest that the Government is about to break them. What some of the men seem to see is the inability of the Government to enforce the agreements. We are therefore back at the old source of trouble. But it is just at this point where the experienced trade union leader is of value, and also at the point where the men have ignored these self-same leaders. Now, to our mind, it is largely here where the men fail in the eyes of the other members of the public. Not that a great many of these are worth taking notice of, because their opinions can be of little value, as they have no insight whatever into workshop conditions. On the other hand, most business men are keen in their desire to abide by agreements. Trade unionists no less than employers of labour should stick to them. There is this to be said for the employers, that they scrupulously abide by the actions of their duly-appointed representatives through their own organisations. Their business experience and interests teach them that such is the best course. On the other hand, how often has this simple rule been ignored on the men's side during the past 12 months, with results at the finish not creditable to the men, whilst leaving, in addition, rankling sores which remain open and cause constant irritation and dissatisfaction.

*(Continued on page 353.)*

## SETTING STEAM BOILERS:

### WITH PARTICULAR REFERENCE TO LANCASHIRE AND CORNISH BOILERS.

By EDWARD INGHAM.

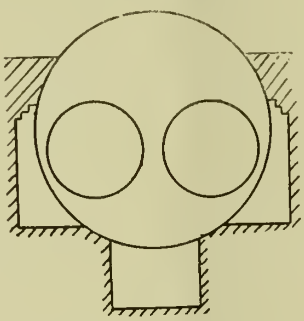
*(Continued from page 336.)*

IT occasionally happens that a boiler has to be placed in a comparatively small space, so that a restriction in the width of the flues is unavoidable; but this is very bad practice.

It is usual to make the width of the bottom flue one-half the diameter of the boiler.

The depth of the flue, *i.e.*, the distance from the lowest part of the boiler shell to the bottom of the flue should be made 2 ft. 6 in. deep or 3 ft.

Generally speaking, it is only in connection with old boilers that seriously contracted flues are met with. In the early days of steam boilers it would appear that boiler setters held the opinion that by keeping the external flues of small sectional area, economy in working would be effected, since the hot gases passing through would be kept closer to the boiler plates. The result was that the flues were often so contracted that it was impossible for a man to pass through them to make a satisfactory examination. It would also appear that that very broad brickwork seatings were believed to be necessary for stability, judging from the large masses of brickwork which were made to bear against the boiler plates.



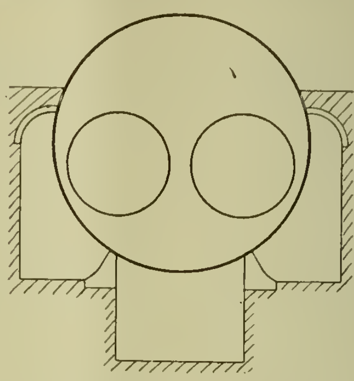
SETTING STEAM BOILERS.—FIG. 2.

An example of an early form of setting for a Lancashire boiler is given in Fig. 2. Now, a setting of this form is not only very objectionable because of its restricted flues, but because of the large amount of plate which is covered over by the broad brickwork bearing surfaces.

It has already been pointed out that brickwork is porous and readily absorbs moisture, and there is nothing which causes such rapid external corrosion of the boiler plates as damp brickwork. Hence, these broad brickwork surfaces bearing against the plates are liable to give rise to extensive wasting, and in the past probably more explosions have occurred from this cause than from any other. The risk of explosion from this cause is, of course, aggravated by the fact that since the plates are covered over, they cannot be inspected, so that any corrosion which may be taking place is liable to proceed undetected until the thickness of the plates is reduced to a dangerous extent.

There is absolutely no necessity for broad brickwork seatings, and these are always avoided in present-day practice. It is usual nowadays to let the boiler rest on specially-prepared fireclay seating blocks, as shown in Fig. 3. By the use of such blocks a number of advantages are obtained. In the first place, the width of the bearing area is greatly reduced, so that a much less area of plate surface is covered up. Further, fireclay is not so porous as brickwork, and is therefore less liable to set up corrosion.

Again, the blocks serve to lift the boiler well above the bottom of the side flues, so making the side flues more accessible, and at the same time preventing the possibility of accumulations of water from resting against the boiler plates and setting up corrosion. It will be seen that in the setting shown in Fig. 2 should any water collect in the side flues, it will rest against the plates and cause external wasting. Accumulations of soot and flue dust, which are extremely bad conductors of heat, would also rest against the plates and so impede the heat transmission from the hot gases to the water in the boiler. By the use of the seating blocks these objections are overcome.

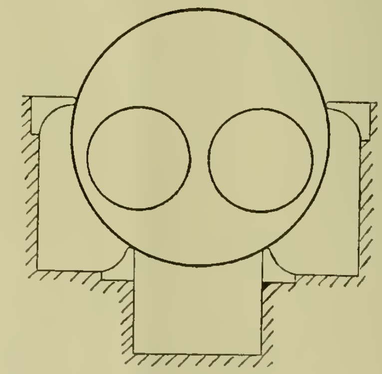


SETTING STEAM BOILERS.—FIG. 3.

For covering over the tops of the side flues special fireclay quarter-circle tile blocks are used, these being covered over with brickwork or flagging.

Now, whilst the form of setting shown in Fig. 3 is immensely superior to the one shown in Fig. 2, it cannot be said to be the best. A much better form is that known as the "Poulton," in which every part of the setting which bears against the boiler plates is made of a rounded form, as represented by Fig. 4.

With this arrangement the area of plate covered over by the setting is reduced to the absolute minimum. The boiler, in fact, rests on surfaces which may be said to have no appreciable width. The result is that practically no surface of plate is hidden under brickwork, and the tendency for corrosion under the seatings, etc., to occur is almost entirely obviated. Further, the whole of the boiler externally is fully open to inspection, a most important feature.



SETTING STEAM BOILERS.—FIG. 4.

In the ordinary form of setting shown in Fig. 3, the width of the seating blocks at the part which is in direct

contact with the boiler is usually three inches, but it is often more than this, so that at each seating there is a strip of plate some three or four inches wide, and in the case of a boiler of standard length (30 ft.), say 26 ft. long, hidden from view. Not only does this mean risk of corrosion under the seatings, but it also means the loss of valuable heating surface, and consequently slightly increased cost in fuel. The same thing applies, generally speaking, to all other parts of the setting which bear against the boiler plates, such as the division and partition walls, the front cross and blow-out recess wall, flue covers, etc. Since, in the "Poulton" form of setting not only the seatings, but all parts which bear against the plates are made of the rounded form, it will be quite evident that this form of setting offers great advantages over the ordinary one.

Owing to the liability of corrosion taking place under brickwork, the Board of Trade and the various boiler insurance compaanies insist on steam users baring the plates of their boilers, more particularly at the seams, at intervals of a few years in order that any corrosion which may be taking place can be discovered before it becomes dangerous. When the setting is of the "Poulton" form this course is not usually necessary, because the amount of plate concealed is almost negligible.

This baring of the plates is most necessary at the seams, because it is at the seams that a boiler is weakest. So far as the seatings are concerned, each seating block which comes against a seam should be removed, and in order to do this it will be necessary to remove certain bricks from the bottom of the side flues. With the object of saving this

Setting Steam Boilers.—Fig. 5.

labour, those blocks which come against the seams may be made in two pieces, as shown in Fig. 5, the upper part being left loose, so that it may be withdrawn when required to enable the plates to be examined thoroughly.

Another plan sometimes adopted is to cut away the top of the block or blocks at the seam, and to provide a piece of fireclay for filling in the gap so made after examination.

With regard to the flue covers, it is necessary to plough through the brickwork at each seam for a width of about one foot.

The length of time which should be allowed to elapse before baring the plates of brickwork will, of course, depend upon circumstances. If the boiler be fixed in a dry situation, and if the width of the bearing surfaces be not great, it will be sufficient to bare the plates every seven or eight years. When, however, the situation is a damp one, and the bearing surfaces are wide, the plates should be bared much more frequently. Whenever there are evidences of damp about the seatings or flue covers, it is advisable to bare the plates at the parts concerned at the first opportunity.

With the object of obviating the trouble and expense which baring of the plates at the flue covers involves, special flue covers are sometimes made which can be lifted up and turned back so as to enable the plates to be examined conveniently at any time.

With regard to the Poulton form of setting, it is sometimes objected that the rounded blocks are quite unsuitable for supporting a heavy Lancashire boiler. Many appear to think that unless wide bearing surfaces are provided, crushing of the material will occur, but that this is not the case may be readily proved by means of a simple calculation.

We may assume the crushing strength of the material from which the blocks are made to be ·7 of a ton per square inch, although a good quality of fireclay will stand rather more than this. The length of the supporting surface for a Lancashire boiler 30 ft. long may be taken to be 26 ft., so that if we assume the width of the seating blocks at the part on which the boiler rests to be 1 in., the supporting area will be $26 \times 12 \times 2 = 624$ square inches. This area will just support a total load of $624 \times {\cdot}7 = 436{\cdot}8$ tons, which is several times the weight of the largest Lancashire boiler ever made, even when filled with water. We have also neglected entirely the support offered by the front cross wall, etc. It is clear, therefore, that a bearing width of less than 1 in. is sufficient to support the heaviest boiler, and the absurdity of making seating blocks 4 in. and even 5 in. wide will be apparent. In the case of the round-nosed blocks it should be obvious that with the least amount of crushing, the bearing surface would immediately be increased, thus obviating the tendency to any further crushing. In one or two instances we have heard engineers express the opinion that seating blocks are liable to wear as a result of vibration of the boiler on its seating, the constant vibration causing a rubbing action on the blocks and consequent wear. For this reason the round-nosed blocks have been regarded as unsuitable. This theory seems to be a somewhat fantastic one, and it is certainly difficult to believe that a boiler can be constantly rubbing the tops of the seating blocks away. In any case, examination of large numbers of blocks which have had large boilers resting on them for many years has not revealed in a single instance any sign of wear.

*(To be continued.)*

## "THE DANGERS OF THE GERMAN PATENT SYSTEM."

By James Keith,

M.Inst.Mech.E., Assoc.M.Inst.C.E., M.Inst.Mar.E. (Eng.), Mem.Am.Mech.E., New York (U.S.A.), etc.

An article has recently appeared in the *Engineer* under the above-named heading, which, although of a somewhat technical nature, is of great importance to British as opposed to German interests, and cannot fail to interest and have the support of every patriotic citizen, whether technical or not. This is the only apology—if one be needed—for the present article. The admirably strong line which you have taken up on the German question justifies one in hoping that you will help the interests of British inventors and the nation at large by giving the assistance of your powerful advocacy to remove what is a national scandal, the result of which outrageous anomaly—doubtless unintentionally but none the less certainly—is to further the interests of German patent pirates to the most serious detriment of British interests. The man in the street or the ordinary citizen of the Empire can have little idea of what has been going on silently but surely for years, at the instigation of the German Government, against the vital interests of the British race. How in the name of patriotism and common-sense the British Government could have framed new rules—*since the war began*—for the benefit of, and made new agreements

with, the Hun barbarians: the result of which is to increase the dangers of the German patent system entirely against British inventors: is more than any ordinary individual can understand.

It has been stated over and over again by those who know that the Teutons are neither a clever nor an inventive people, unless it be in the art of thieving, *i.e.*, in so-called "improving" on, or copying, the inventions of more civilised countries: and as the article in question truly puts the matter, "the German by his patent system has indeed, during many years, formed a powerful means of commercial and industrial espionage for Germans," as, unquestionably, the system was designedly framed for and meant to do.

Speaking from one's own experience, a German thinks that everything good comes from Germany, and that an invention from any other country is not an invention at all: and, unfortunately, he has been encouraged in that belief, not only by the action of the British authorities, but by the procedure of other outside nationalities in—as has been so well put in the said engineering article—the "belauding of the German patent system to such an extent that the Germans have so far succeeded in centralising in the archives of their Patent Office almost all the work of inventive genius in the Old and New World."

Presumably "foreign" inventions are not philosophical enough for the "kultured" Germans, and if Germans are able (as they are) to obtain patents for inventions conceived by British subjects who are unable to obtain patents, then it is probably due to this Teutonic self-conceit of which dishonesty or stupidity are only minor traits, and of which habit it is to be feared nothing will cure the Germans but the shooting of them off the face of the earth, as the Allies are so righteously trying to do at the present time.

Surely, after the present world's war, with all its German horrors, no civilised or humane being outside the Central Powers—in strict accordance with the Paris resolutions—desires willingly to have any further dealings, business or otherwise, with any of the Hun race: hence, why should Germany and all its works not be religiously barred from at least this country for a generation or two, when there need be no more trouble from such German patent system dangers as those portrayed in the article in question?

Where the writer of the article has shown very considerable wisdom is in pointing out that Germans themselves have set afloat the theory that there is some magic in a German patent, and the people outside generally have been led to believe that if an invention is not patented in Germany it can't be worth a rap, while, if it is patented in Germany, it must be a marvel! There are quite enough imperfections in our own British patent system to keep us all humble: these, however, are our own business, but now that we have the chance it is also our business to see that we get rid, once and for all, of the dangers of the German patent system so much affecting our British patent policy, by precluding the granting of any more British patents to any alien of Teutonic nationality, and by the forfeiture of all existing British patents owned by unnaturalised Germans or Austrians, whether living in British territory or out of it.

As the author, during the past fifty years more or less, of many patents at home and abroad, and as one who claims to have done his level best—and with some success—to bring about reforms in our British patent laws, the present writer feels that he knows what he is talking about when he states that, so far at least as the engineering profession goes, our future progressive procedure and success in the world's business will in no small measure depend on (*a*) our bringing about vital reforms in our British patent system, (*b*) freeing it from something like the dangers pertaining to the German system, and (*c*) on getting it more into line with the system in vogue on the other side of the Atlantic. If it were advisable—which it is not during the present crucial war-time—one could give instance after instance in which applications by British inventors for protection in Germany have, after the necessary full disclosure which is compulsorily required on application in Germany—been refused by the German authorities, then only having been slightly "improved" on, or, in other words, stolen by the German from the British inventor, application has been by these German patent pirates made to the British patent authorities, and patents have actually been accepted in favour of these same Germans, although protection for the said inventions had been already granted by the British Patent Office to the actual British inventor in this country. Could fatuitous folly go further? All because of the new rules made between the British and German Governments in the end of 1914, *after the war had begun*, much to the detriment of *bona-fide* British invention. While, therefore, such imitation acceptances, when actually *granted* and *sealed* after the war is over, presumably remain legally invalid, if tested in a Court of Law, still a deal of harm must be done meanwhile by the publication of the accepted printed specifications, it being provided that however gross the apparent infringement, by the new rules, no revocation proceedings can be instituted by the original British patentees and inventors until the end of the war. The Prime Minister in his great speech at the Guildhall the other day, vividly brought home to his hearers the submarine menace of Germany when he spoke of the "swarm of pirates moving unseen in the trackless sea," "infesting our home waters and our ocean routes, seeking to prey on our merchant shipping like sharks on small fishes."

We all know that there are land sharks as well as sea sharks, and the Germans—quite in keeping with their piratical, secret, and cowardly methods on the sea and under the sea—have for years been carrying on the same dishonest and unscrupulous proceedings on land against all our business interests, and especially against our progress in invention, if these should in any kind of way conflict with German business interests.

In the concluding paragraph, therefore, of the article in question, the writer is perfectly right in throwing the blame on the citizens of Allied and neutral nations, "if their eyes have not yet been fully opened to the danger underlying the German patent system, if they should continue to assist in any kind of way in the development of the industrial manufactures of Germany by placing the results of their inventive genius at the disposal of a Department whose object is declared to be the communication to interested parties, on the filing of the applications, of all discoveries capable of furthering the prosperity of the German Empire."

Certain it is that the Germans do not obtain really *valid* British patents (in law) for trifling modifications of inventions already patented in Great Britain, and it is not quite understandable why the British Patent Office refuses to proceed with oppositions by British subjects to British applications of enemy subjects. There would be some justification for its refusal to proceed if the Patent Office ultimately meant to refuse to grant or seal the patents, because there would be no use in the Patent

Office wasting money over applications that were never to mature into real or valid patents.

The practice of the Patent Office in this respect might be justified by argument, but then it is inconsistent with the circumstance that the British Patent Office would be wasting public money in examining such applications at all.

Of course, it must never be forgotten that if there is any useful information in patent specifications received from Germany, the public can get the information by consulting the published specifications. If, however, as is probably the case, it costs (under the 1907 Act) the British Patent Office more to examine an application than the fees paid, then it might be considered that the examination of applications received from Germany was another instance of public extravagance entirely unwarranted by results, and especially during the time of war.

It is, of course, notorious that the British Patent Office has a large surplus revenue, but, according to general understanding of those in the know, the said surplus is due almost entirely to the heavy taxes payable, and the so-called examination of applications is conducted at a loss, or, rather, the examination costs more than the stamps on the application forms and specifications. Why, therefore, should public money be wasted by the British Patent Office on the examinations of specifications from Hun lands at all?

In this connection, and quite *apropos*, let it be noted that that gifted statesman, the Right Hon. D. Lloyd George, the accredited author of the rather unfortunate British Patent Act of 1907, eloquently perorated some little time ago before his fellow-countrymen in Wales as follows:—

"When the smoke of this great conflict has been dissolved in the atmosphere we breathe, there will reappear a new Britain. It will be the Old Country still, but it will be a new country. Its commerce will be new. Its trade will be new. Its industries will be new. There will be a new condition of life and of toil for Capital and Labour alike, and there will be new relations between both of them and for ever. But there will be new ideas. There will be a new outlook. There will be a new character in the land."

All of which, when duly accomplished, as, thank God, let us hope will soon be the case, will solve most of the difficulties under which we in this old land labour, and ought particularly to enable the country to get rid of, for all our time at least, any kind of danger arising from the application of any form of the German patent system, or of any other equally noxious growth inside our own (let us hope by that time) reformed British Empire patent organisation.

As a rule, dissertations on patent matters are considered to be highly technical: in the present instance, however, the whole discussion has been based more on economic or moral grounds (and no confusing figures have been used sinister to the non-technical mind) in order that all patriots who rightly consider that the British Empire stands for the greaest power for good in the world may understand and appreciate its full significance.

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Electric Furnaces of Sheffield.—The electric furnaces of Sheffield alone can now produce 90,000 tons of steel per year, and in 1918 it is anticipated that the output from these furnaces alone will be 150,000 tons.

# METAL MELTING*

By H. M. Thornton, M.I.Mech.E., and Harold Hartley, M.Sc.

## The Melting of Brass and Copper in a Crucible Furnace with Coal-Gas Fuel.

The marked success achieved by furnaces employing coal-gas as a fuel, in the heat treatment of metals such as steel, is proving of material assistance in the introduction of gas-fired, metal-melting crucible furnaces. Although it would be premature to claim that these latter are fully established, nevertheless, as will be seen from the data to be given later, they offer great possibilities.

It is proposed in this communication to deal only with a furnace of the type intended for melting the metals of higher melting point from brass upwards, as we feel that in this direction coal-gas and water-gas are especially capable of giving the desired results.

### General Considerations.

In working with coal-gas the fact must not be overlooked that in terms of B.Th.U. available the fuel is costing from four to five times as much as coke, assuming the gas supply to give 500 B.Th.U. per cubic foot net at a cost of 2s. per 1,000 cubic feet, and even with water-gas the fuel is considerably more costly per B.Th.U. than the coke which it is intended to replace. Starting with this disadvantage, the furnace manufacturer has either to obtain a markedly greater thermal efficiency out of his appliance or to effect economies in other directions, such as a decrease in the metal losses, greater life of pots, increased daily output per furnace, with a corresponding decrease in establishment charges per cwt. of metal melted, by a saving in labour charges, or by a saving in foundry space, all of which tend to the desired increase in over-all efficiency and can be translated ultimately into £ s. d. It is probable that the cast metal prepared with the gaseous fuel would give better results than that obtained by coke melting in those cases where sulphur content is an important factor.

### Fuel Consumption.

Just as in the case of solid fuel, this is determined with a given furnace by the specific heat of the solid metal between the temperature of the atmosphere and the melting point, the latent heat of fusion, and the specific heat of the molten metal. The effect of this latter factor may be very important in those cases where a high degree of fluidity is required or desired for any specific purpose.

### Temperature of Molten Metal.

When asked to quote fuel consumptions, the furnace manufacturer may feel himself in somewhat of a quandary unless the melter can provide some fairly precise information as to the pouring temperature required, and in the test data given later we have included the temperature of the metal before pouring, just before the crucible was lifted out of the furnace. These temperatures were obtained by means of a Pt/PtRh thermocouple.

In our work with brass and copper, the pouring temperature has ranged about 100 deg. to 150 deg. Cen. above the liquidus. We have found such temperatures generally satisfactory for work of a varied nature carried out in our pattern foundry. In this connection it is of interest to recall the work of J. M. Lohr published in 1913 and abstracted in the Institute Journal, in which

* Paper read before Institute of Metals, March 22nd, 1917.

the conclusion is drawn, after an examination of the copper-zinc alloys, that the best pouring temperature is between 100 deg. and 200 deg. Cen. above the liquidus, a higher pouring temperature always producing an oxidised casting. Longmuir's work* also indicates that very hot metal does not give the best results.

Certain workers advise raising the temperature of the metal to a point in excess of that necessary for casting, and then after drawing the crucible from the furnace holding for a sufficient length of time until the mass has cooled to a suitable extent. We notice, however, in a recent article on this subject,§ that it is stated, with reference to brass melting, overheating is not advisable, as there is always the danger that it will lead to honeycombing, which is not completely avoided if the metal is cooled before pouring.

Turner and Thorneycroft state† that considerably more heat is requird to liberate zinc from alloys rich in copper than to volatilise the liberated zinc, and they give the ratio of the amounts of heat required for the processes as 94 : 6 as a first estimate.

## Brass Melting.

Starting from cold a certain amount of energy is required to heat up the bodywork of the furnace, and the additional fuel needed for this purpose acts as a handicap in the endeavour to obtain low average consumptions, the over-all effect of which is decreased by increasing the number of melts carried out successively. For the forth and subsequent melts it is found generally that the gas consumption per lb. of metal melted remains practically constant. In the last melt of the day a small saving is effected, owing to the fact that there is no excess of brass in the metal preheating chamber, and in consequence the degree of preheating of both the metal and air increases. If time will allow it is possible to increase this saving by a judicious checking of the gas supply and consequent abstraction of heat from the furnace walls, as the combustion chamber will be considerably hotter than the crucible and its contents.

Below are given results of a typical run, limited to six melts to avoid repetition, and added are the average consumptions on the basis of 12, 15, and 20 melts.

BRASS MELTED.

(General scrap and ingots obtained previously from mixed scrap. For approximate composition see "Original Metal," p. 7.) Brass and air preheated.

| No. of Melt | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Weight of metal charged (in lbs.) | 68 | 68 | 68 | 68 | 68 | 68 |
| Including scrap | 8 lbs. 14 ozs. | 3·15 ozs. | 2 lbs. 9 ozs. | 6 lbs. | 7 lbs. 10 ozs. | 6 lbs. 11 ozs. |
| Amount of metal preheated | 12 | All | All | All | All | All |
| *Gas.* | | | | | | |
| C. ft. per lb. metal melted | 4·93 | 2·09 | 1·78 | 1·66 | 1·60 | 1·40 |
| Cal. val. net | | | 554·8 B.Th.U. per c. ft. | | | |
| B.Th.U. per lb. metal melted | 2644 | 1121 | 955 | 891 | 858 | 751 |
| Pouring temperature | | | 990° C. to 1010° C. | | | |
| Duration of melt in minutes | 86 | 38 | 34 | 31 | 31 | 30 |
| Weight of skimmings | | | 10 lbs. | | | |

On the basis of these figures, the temperature rise caused by the addition of zinc to molten copper can be calculated. A considerable rise of temperature occurs. The addition of zinc to molten yellow brass does not appear to cause a rise in temperature of the mass, nor does it appear to arrest the cooling of the metal. The following temperature determinations were made on plunging zinc in lump form into 70 lb. of molten yellow brass (70 per cent copper):—

| Time (mins.). | Temperature. °C. |
|---|---|
| 0 | 1132 |
| 1½ | 1115 (1 lb. of zinc added) |
| 2 | 1108 |
| 3 | 1088 (1 lb. of zinc added) |
| 4 | 1062 |

In an abstract in the Journal of the Institute for 1914 is given a list of various commercial brasses with the temperatures at which they pass completely into the liquid state.‡ From this list the following are taken:—

| Metal. | Cu. | Zn. | Sn. | Pb. | Melting Point. |
|---|---|---|---|---|---|
| Gun metal | 88 | 2 | 10 | .. | 995 |
| Red brass | 85 | 5 | 5 | 5 | 970 |
| Half yellow / Half red | 75 | 20 | 2 | 3 | 920 |
| Cast yellow brass | 66·9 | 30·8 | .. | 2·3 | 895 |
| To these we add : | | | | | |
| Copper | .. | .. | .. | .. | 1084 |
| Copper, 3·5 per cent cuprous oxide | .. | .. | .. | .. | 1065 |

Sawdust added to decrease oxidation. No flux used. No zinc added prior to pouring.

SUMMARY.

| | Gross Consumption per lb. Metal Melted. | B.Th.U. per lb. Metal Melted. |
|---|---|---|
| | Cubic Feet. | |
| Average for 6 melts | 2·25 | 1203 |
| ,, 12 ,, | 1·92 | 1031 |
| ,, 15 ,, | 1·86 | 996 |
| ,, 20 ,, | 1·79 | 962 |

If it be desirable to raise the temperature of the brass 100 deg. Cen. higher than that in the above test, then it is estimated that the gas used per lb. of metal melted would be increased 20 per cent.

## Metal Losses.

The weight of dross is sometimes unduly swelled, owing to the moulder putting his skimmer too deeply into the metal, and this we find more often to happen when no flux has been added to form a protective covering.

To some extent opinion would appear to be divided on the question of the desirability of employing a flux in brass melting, and no doubt the decision taken in many cases is largely determined by the final temperature required. When it is intended to work with very hot

* *Journal of the Iron and Steel Institute*, 1903 and 1904.
§ *Metal Industry*, Oct. 13th, 1916.
† *Journal of the Institute of Metals*, 1914, Vol. xii.
‡ Gillett and Norton, *Metal Industry*, 1914, Vol. 6, p. 12.

metal it may be thought to be advantageous to use a flux, on the ground that it would form a more impervious covering than charcoal and thus lessen the volatilisation of zinc.

When a flux is used the weight of metal cast appears to differ less from the weight of metal charged than when only charcoal is used, due apparently to brass becoming intermingled with the charcoal in the latter case. Analyses, to which attention will be called later, of two brasses remelted several times (*a*) with a sawdust covering, (*b*) with common salt as a flux, indicate that the loss of volatile constituents is much the same even when the metal is rendered very hot. In the same series of tests the weights of dross withdrawn from the pot were:—

(*a*) From 1 lb. 4 oz. to 1 lb. 8 oz. per melt.
(*b*) 14 oz. in melts 1 to 4, 8 oz. in melt 5. Weight of salt added originally, 4 oz. per melt.

McWilliam and Longmuir* state that the best quality alloys are always produced without fluxes, and extensive experiments in this direction are not at all favourable to any type of flux during melting."

In an article dealing with the manufacture of cartridge brass, C. R. Barton† recommends the use of common salt as a flux and phosphor copper as the deoxidiser in crucible melting, and further mentions that this type of furnace is preferred for the work despite the relatively high cost of crucibles, which, he says, have on the average a life of 25 melts (200 to 220 lb. size) in coke-fired furnaces.

For ourselves, we find a certain amount of inconvenience attached to working with a salt covering, owing to the acid fumes produced. This flux appears to attack the crucibles markedly, and if thrown into the furnace at all carelessly may be blown into contact with the outside of the pot and rapidly end its days. Deterioration of the firebrick lining due to the salt would depend apparently on the temperature of the furnace when the salt came into contact with the walls. If the fireclay was hot enough to form a glaze at once, no great trouble would be anticipated; on the other hand, if the temperature were lower and the NaCl vapour had an opportunity of diffusing into the brickwork and reacting with it later, the result would be unpleasant.‡

On the other hand, salt is stated§ to be useful in small quantities, admixed with charcoal to prevent absorption of sulphur by molten copper and its alloys; and to lessen the retention of viscid metal by the dross.

The fluxes used more generally are calcium fluoride, glass, and potassium hydrogen sulphate.

We ourselves incline to the view that the most satisfactory results are obtainable by the use of a charcoal or similar covering, together with a small amount of flux.

In an inert atmosphere the rate of loss of zinc from a given brass will depend on the temperature and the speed of flow of the gases over the metal. During melting the process may be accelerated, owing to the oxidation of the zinc vapour and consequent reduction of the partial pressure of the metallic vapour. The effect of this latter factor is decreased to some extent if the combustion of the gases is not completed in the pot chamber, and still further if a covering of charcoal is employed.

In the final heating stage, after the metal is molten and when the greatest loss occurs, a crucible lid previously heated in the metal preheating chamber can be used to cover the pot and decrease the loss.

Assuming that it requires in the respective furnaces 3·0 cubic feet of coal-gas, or 0·5 of coke per lb. of metal melted; then if the gas is burnt completely to $CO_2$ in the pot chamber, the volume of products (calculated at 0 deg. Cen. and 760 mm.) will be about 14 cubic feet, whereas with the coke if it burns to $CO_2$ there would be about 77 cubic feet of products, and if only CO were formed, about 45 cubic feet. From three to five times the volumes of products flowing through the gas-fired furnace pass through the coke furnace.

In brass melting in coke crucible furnaces the zinc loss is stated often to be large, in which case it must be an important factor, both from the economic point of view, which is of especial moment at present, and, unless corrected for prior to pouring, with regard to its effect on the mechanical properties of the resulting alloy.

Statements have been published that in the process of melting brass, as generally carried out, about 20 to 25 per cent of the weight of zinc originally added is lost; compensation is made for this by plunging a piece of spelter into the molten bath and involve a still further loss of metal.

McWilliam and Longmuir cite the case of a manganese bronze which they remelted in a crucible furnace (coke?) to determine the zinc loss. They give the following analyses*:—

| | Original Metal. | Remelted and Sand Cast. |
|---|---|---|
| Copper | 59·00 | 68·88 |
| Tin | 0·58 | 0·86 |
| Zinc | 37·92 | 28·13 |
| Iron | 1·40 | 1·45 |
| Manganese | 0·42 | 0·23 |
| Aluminium | 0·48 | 0·20 |

Unfortunately no details are given of the period of heating or of the temperature attained. It will be noticed that the zinc loss is about 25 per cent, and the manganese loss about 50 per cent. Further, these authors state that they estimate the original metal would have a maximum stress of 25 to 28 tons per square inch, whereas the remelted metal would not sustain more than 15 tons per square inch.

They also give a series of results showing the losses in making different brasses "in typical crucible furnaces": these vary from 28·6 per cent in the case of red brass, when a temperature of 1,308 deg. Cen. was attained, to 19 per cent when making Muntz metal, the maximum temperature in this latter case being 1,038 deg. Cen.

We have investigated this point in connection with gas-fired furnaces, and although anticipating some saving, the great difference between our results and those of the authors just quoted cannot be put down solely to the credit of the gas furnace.

The high loss of zinc in the remelting of the above manganese brass is conceivably due, in part at least, to the presence of the $\beta$ phase in that particular sample, as Thorneycroft and Turner* have shown that the $\beta$ alloys part with zinc much more readily than the $\alpha$ solutions with which we were concerned. Further, according to Thorpe's Dictionary,† 5 per cent represents the maximum loss of zinc usually experienced in the making of brass when the volatile constituent is added to the copper in large pieces.

* "General Foundry Practice," 2nd edition, p. 328.
† *Journal of the Society of Chemical Industry*, July 15th, 1916, p. 740.
‡ Cobb, "Effect of Salty Coals on Coke-oven Linings," *Journal of Gas Lighting*, March, 1916.
§ *Metal Industry*, Feb. 23rd, 1917. Abstracted from *Brass World*.

* *Loc. cit.*, p. 360.
* *Loc. cit.* † Vol. v, p. 816, "Cast Brass."

VARIATIONS IN COMPOSITION ON REMELTING BRASS REPEATEDLY.

Series A.

| | Original Metal. | Remelts. 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Copper (by difference) | 70·57 | 71·44 | 71·76 | 71·67 | 71·54 | 73·27 |
| Zinc | 24·77 | 24·65 | 24·45 | 24·15 | 23·63 | 22·14 |
| Tin | 1·34 | 1·24 | 1·19 | 1·15 | 1·38 | 1·29 |
| Lead | 2·99 | 2·22 | 2·04 | 2·60 | 2·93 | 2·75 |
| Iron | 0·33 | 0·45 | 0·56 | 0·43 | 0·52 | 0·55 |
| Duration of heating period (in minutes) | .. | 122 | 44 | 40 | 30 | 53 |
| Pouring temperature | | 990° C. | to 1015° C. | | | 1180° C. |
| Weight of skimmings | .. | 21 ozs. | 22 ozs. | 24 ozs. | 24 ozs. | 24 ozs. |

Series B.

| | Original Metal. | Remelts. 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Copper (by difference) | 70·01 | 70·24 | 70·29 | 70·50 | 71·08 | 72·45 |
| Zinc | 25·29 | 24·97 | 24·72 | 24·46 | 23·96 | 22·68 |
| Tin | 1·30 | 1·21 | 1·26 | 1·30 | 1·37 | 1·29 |
| Lead | 2·78 | 3·12 | 3·19 | 3·29 | 3·27 | 3·12 |
| Iron | 0·62 | 0·46 | 0·54 | 0·45 | 0·32 | 0·46 |
| Duration of heating period (in minutes) | .. | 95 | 40 | 34 | 29 | 58 |
| Pouring temperature | | | 990° C. to | 1015° C. | | 1180° C. |
| Weight of skimmings | .. | 14 ozs. | 14 ozs. | 15 ozs. | 14 ozs. | 8 ozs. |

*Zinc Loss during Remelting; per cent Zinc present Originally.*

| Melts No. | 0 to 1 | 1 to 4 | 4 to 5 |
|---|---|---|---|
| Series A | 0·48 per cent | 4·26 per cent | 6·19 per cent. |
| Series B | 1·34 ,, | 4·04 ,, | 5·63 ,, |

H. W. Gillett‡ states that in current practice of brass melting 5 per cent of the original metal is lost; later he says that reports of metal losses vary from 1 per cent to 22 per cent.

Recently, in making up a red brass containing a little tin in four 50 lb. lots we found the average zinc loss not to exceed 3·0 per cent.

In connection with the determination of zinc loss on remelting yellow brass, the following tests were made.

Two 70 lb. lots of works scrap brass A and B were melted and cast into chills, sample ingots being retained for analyses. Batch A was then remelted with a covering of sawdust only, cast into ingots, a test ingot withdrawn, and the remainder returned to the crucible, remelted, and a further sample taken. This treatment was repeated, five remelts in all being made. In the last melt, after the pourers had approved the metal to be sufficiently hot for casting purposes, the crucible was left in the furnace for another half-hour, the temperature of the metal being raised steadily during the whole of this period.

The second batch of metal B was treated in a similar manner, except that in this case a covering of common salt was employed, and no provision of charcoal made for the prevention of oxidation. In neither case was a crucible lid used. The analyses of the various ingots withdrawn during the series are given above. These test ingots weighed about 3 lb. each.

The loss occasioned by heating to 1,180 deg. Cen. was about 4½ times the average loss in each of the preceding melts.

*(To be continued.)*

‡ *Bulletin of the U.S. Bureau of Mines*, 1914.

## ADDRESS BY MR. MICHAEL LONGRIDGE TO THE INSTITUTION OF MECHANICAL ENGINEERS.

*(Concluded from page 335.)*

### Employers and Employed.

Now I come to a problem of far greater difficulty, the negotiation of a treaty to secure a lasting peace between employers and employed. Without this peace the victory over Germany, for which we have sacrificed so much, will be in vain. The future of the British Empire depends on its attainment.

I hope the trade unions will have learnt, before the war is over, that a policy which compels a workman to limit his output and his earnings, which refuses a manufacturer a due return on the cost of installing up-to-date machinery, and on expenditure for scientific research, is as injurious to the workman as to his country, and that if persisted in it will ultimately ruin both, even if it bring particular unions some temporary gain. If we are to compete successfully with nations in whose industrial vocabulary "ca' canny" finds no place, limitation of output and restrictions on working machinery will have to be given up. But if the unions be wise enough to give up voluntarily what we have undertaken to restore, we are in honour bound to give them some acceptable equivalent.

For 100 years employers and employed have been at war, and war leaves bitter memories. The war began when the tools of his trade were transferred from the workman to his master, and he became dependent for permission to use them on his master's will. The law forbade him to improve his lot. With the exception of a

few men like Robert Owen and Michael Sadler, employers as a class for many years consistently opposed all legislation making for the health and safety of the workers. The workers know, too, that some employers refuse to recognise the unions even now.

Employers also should consider how far limitation of output, and objections to piece-work, profit-sharing and co-partnership, two of the most serious causes of difference with the unions, are due to their own short-sighted policy in cutting piece-work rates. The case has been very plainly put by Mr. Barnes, M.P. "The system," he says, "has been a failure because, in the stress of competition, piece-work earnings have tended to slide downwards to what previously had been a time-work wage." Indeed, it would almost seem to have been an article of economic religion that a workman's earnings should be limited by precedent. And thus we go on in a vicious circle, the master unable to increase wages because the workman will not give the necessary output, the workman limiting the output because the master does not raise the pay.

But that is not the only reason why the workman limits output and refuses piece-work. Deeply in his mind is rooted the belief that increased output causes gluetted markets, short time, and unemployment, a terror which casts its shadow over his whole life. This delusion can only be removed by education.

We have to convince the workers by experience, and teach them by education, that piece-work, co-partnery and large output are to their advantage, and that only by putting the best machinery to the best use can high wages, relatively to the cost of living, be maintained.

And here I venture to interject a timely caution. Directly the war is over the engineering trade will have a period of activity without precedent; wages will, if possible, rise, and enormous profits will be made. These profits must not be distributed in inflated dividends, as in the "boom" after the Franco-Prussian war, first, because large dividends will encourage speculative enterprises whose failure will hasten and accentuate the financial stringency and bad trade which must come when the first great boom has to be liquidated; and, secondly, because the money must be saved to keep up wages and employment when the bad times come and the employers' theory of piece-work is put to the test.

To-day piece-work prices are fixed in some places by associations of employers and employed, but generally, I think, the former have had and still have the business practically in their own hands. In the future I hope that not only piece-work rates, but wages, demarcation, and other disputes will be settled jointly by one or other of the associations I have mentioned.

Then there is another matter which will have to be considered soon—the length of the working day. We ask for better education of the workers. We mean to try to give it them. But to enjoy its fruits they will demand more leisure, and I think public opinion will uphold them. It is, perhaps, worth while mentioning that the three great disputes in the engineering trade were concerned with one or other of the subjects I have mentioned, qualification of men to work machines, hours of work and limitation of output. The object and results of these disputes are worth consideration. The lock-out of 1852 was brought about by a demand for the abolition of piece-work and the removal of labourers from machines. The masters were victorious. The strike of 1871 was caused by the refusal of the employers to grant a 54-hours week. The men won. The lock-out of 1897-1898, though it began with a strike on the question of an 8-hours day, was really brought about by interference of the unions with the management of the works, the selection and training of machine workers, objections to the employment of non-unionists; but, above all, by limitation of output.

I plead for understanding and forbearance from employers. You cannot drive 2,000,000 trade unionists, but you can educate and persuade them. "In a national crisis men should think more of what they could give than of what they were likey to get," said a great labour leader to the Manchester Trade Union Congress only three months ago. Can *we* not act upon his words?—the time is ripe. *(Concluded.)*

## WORKS ORGANISATION.*

By A. W. Reeves and Cecil Kimber.

The organisation of an engineering works does not as a rule arouse very marked enthusiasm in the mind of the technical enthusiast, for to such a man routine work, largely of a clerical nature, is by no means attractive. Nevertheless, private engineering enterprises have obviously a very short life unless they are conducted in such a manner that financial profit accrues.

In other words, engineering concerns are perforce required to be run as commercial propositions, and whether the technical enthusiast likes it or not, he is compelled to consider his projects as much from the financial as from the purely technical standpoint.

After a great deal of cancelling out it is inevitably found that, other things being equal, the most essential feature to ensure financial success is "output"; overhead charges, of course, vary inversely with the output.

It may be stated that a business organisation is a set of laws so framed as to provide an orderly method of directing the business energies of a company in a manner similar to that whereby a country is provided with laws which order the lives and activities of her citizens.

The most successful country is generally admitted to be the one with the most really successful laws, and it therefore follows that the success of a business depends upon the laws or organisation by which it is managed. Modern conditions demand that more and more attention should be paid to the organisation or method in which the business is conducted, and it applies as much to the internal as to the external conduct of the business. The former takes care of the production of the article, the latter takes care of its sale.

The following matter is descriptive of a series of rules and regulations framed with the object of guiding the energies of the executive and the operators concerned in the production of an engineering commodity. Technical points are not dealt with at all.

As stated, it is confessedly not a particularly agreeable subject, but unfortunately it is a form of medicine which, if we are out for successful results, we are compelled to take, whether we like it or not.

Little may be said respecting the manufacturing policy adopted by the Directors of the business concerned. It is assumed, however, that (by way of a change from what usually exists in so many British engineering works, including motor-car factories) the controlling Directors have really made up their minds what it is they wish to manufacture, what capital they are prepared to put at the disposal of the concern for that manufacture, and what

* Paper read before the Institution of Automobile Engineers.

quantity of the articles in question are to be manufactured over a given period. If these main essentials are not definite, and the Directors of the Company have flabby and variable ideas concerning them, it would be far better not to commence on the manufacturing scheme at all. It is an unfortunate fact that it is all too common to find the Directors of British engineering concerns as variable in their manufacturing policies as our national climate.

The authors personally doubt whether better methods of organisation have altogether been the cause of much of the so-called German industrial success—it may be very seriously asked whether it is not more due to the German national characteristic of fixity of purpose. One of the authors has some actual experience in this matter, and this, at any rate, is his decided opinion.

The German temperament is solid. He thinks for a long time what it is he is aiming at, and having decided, he goes more or less straight for it. The manufacturing policies of English companies often resemble a Sunday morning walk, in that they are equally aimless, and mostly less profitable. "Chop and change," whether applied to the product or personnel of an engineering works inevitably ends in failure.

The matter of the general lay-out of the plant is not considered here, but in the authors' opinion the time-honoured layout whereby the various types of machines are collected together and put in their own special section is altogether wrong. The authors' principle is not to collect groups of like machines, but, what is quite different, to collect groups of machines necessary for the production of a particular component or group of small components. For example, in the case of motor-car manufacturing the idea is to collect in one section all the machines necessary to produce gear boxes, whilst in another section would be collected machines necessary to produce front axles. The manufacturing policy as to quantity production has, of course, a great bearing on this matter.

On this subject the manufacture of munitions of war has taught many of us a great deal. In fact, the motor vehicle manufacturer, for example, who, owing to war orders has been able to remain entirely employed on his pre-war product, is perhaps to be pitied. He has lost some of the most valuable experience possible, and the authors venture to assert that motor-car factories which have had to turn over to the production of munitions, will, after the war, and as the result of their experiences, be in a most favourable position for competition. The experience will have been a blessing in disguise.

Works organisation is a subject that is so extremely complex that the authors naturally hesitate before dealing with it in the confines of a short paper such as the present one. Nevertheless, when the matter comes to be thoroughly investigated, it is seen that there are certain broad principles to be followed and applied, no matter what the nature of the manufacture. This broad outlook is narrowed when the particulars come to be applied to the engineering trade, and the authors put forward the following manufacturing system or scheme in the certainty that, with slight modifications, it can be adapted to practically any present-day engineering works. It was designed for a works previously engaged on motor-car manufacture, but now, owing to the war, converted into what might be termed a general engineering shop. Its principles, however, apply equally well to a specialised output.

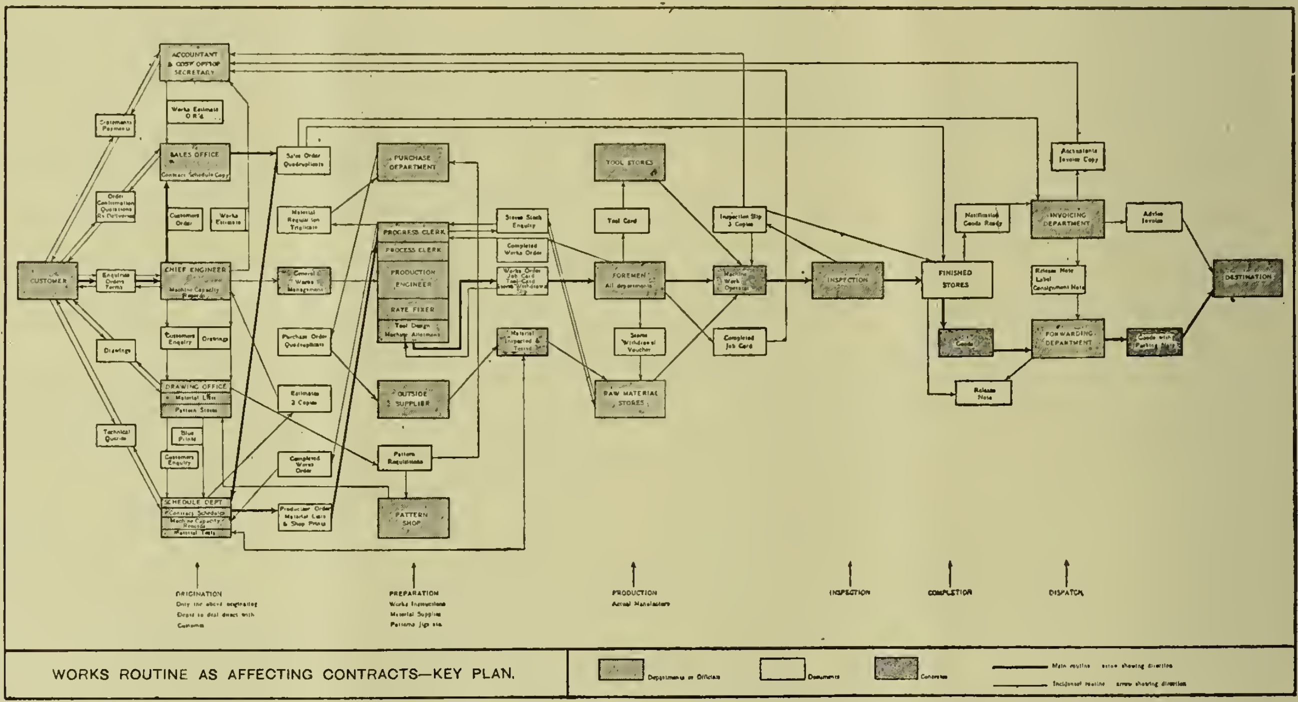



Fig. 1.—Works Organisation: Key Plan of all Departments.

One of the essentials of a works routine is the reduction of documents—and consequent clerical labour—to a minimum, and with this end in view it is essential that the costing and secretarial side of the business should be in full sympathy with the works and shop management.

By use of the authors' diagrams, it is possible for each department to know exactly the extent and scope of their respective duties. This, coupled with a key plan, makes every man conversant with his own duties as well as with those of others.

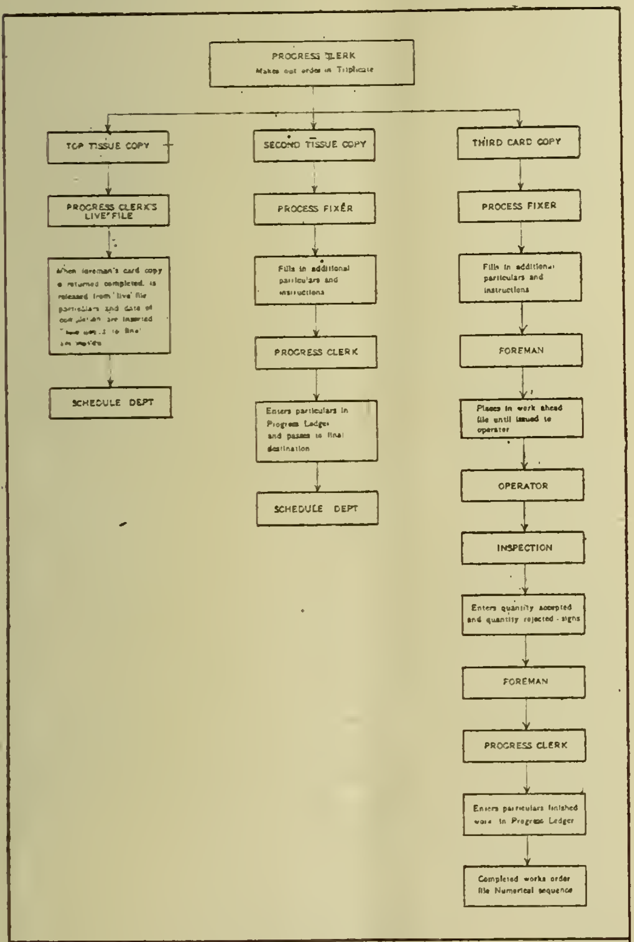
In so many works it is found that each department is a community to itself, each having its own methods of

carrying out its work, but the whole lacking that smoothness of working and co-ordination that is so essential.

It will be seen, therefore, that organisation consists in the dovetailing of the work of one department into that of another, in order to produce the greatest efficiency for the whole, although this dovetailing may possibly reduce the effectiveness of an individual department.

## Broad Outline of Organisation Suggested.

Taking the average works it will be found that the departments can be divided into five main groups or sections, designated on the authors' key plan (Fig. 1) under the titles, "Origination," "Preparation," "Production," "Inspection," and "Despatch." These apply only as




DOCUMENT CHART.
ROUTINE FOR WORKS ORDER OR SUB-WORKS ORDER

Fig. 2.—Works Organisation: Document Route Chart.

far as the execution of a contract is concerned, but this is, after all, the main thing for which the organisation is planned. It will be seen that the departments coming under the heading of "Origination" comprise the Chief Engineer and the Sales, Accounts, Drawing Office, and Schedule (and Estimating) Departments. These Departments are the only ones to correspond direct with the customer, and it is from these departments that the order "to produce" is issued to the works. Hence the term "Origination."

Under "Preparation" we get the various sub-departments controlled by the Works Superintendent, and it is these sub-departments which prepare the order, design the tools, jigs, etc., ready for issue to the shop. Thus everything is "planned out" ahead before actual production is commenced. (See Fig. 12.)

Under "Production" there is, of course, the shop foreman, and the actual operators and machines, whose work has been previously mapped out to the smallest details by experts in the planning department.

Inspection and despatch are self-explanatory. (Fig. 11.)

As far as possible, unforeseen circumstances, that dread enemy of organisation, have been provided for. The idea is for each department to have a copy of the key plan, and a departmental plan prominently displayed in each office, in order that everyone concerned may be thoroughly conversant with the routine. In the case of certain works forms, of which several copies may be issued, each with a different, but vitally necessary, destination, the departmental plans can be supplemented with wall copies of "Document Route Charts" as shown in Fig. 2. In addition to this, plainly worded instructions should be printed on the back of every works form as to the correct procedure to follow. In this manner the training of a new staff, in the event of changes, is reduced to a minimum.

This latter is really a bigger point than many employers and executives imagine, but there must be many members who, especially since the war started, have had the heart-breaking work of drilling and instructing an entirely new and raw staff in the current system of an established works organisation. Above all must simplicity be aimed at in the sub-division of duties and the "unknown contingencies" be guarded against as much as possible.

An important factor to the authors' mind, and one which appears to be entirely ignored in the wonderful works systems originating on the other side of the Atlantic, and among many idealists on this side, is that of the personal or human element. Anyone with any knowledge of the independent and, it must be confessed, "awkward" spirit, characteristing the workers of, say, the Northern Midlands, would hesitate before applying the extreme methods of the latest American "Scientific Management," well knowing the futility of the task. On the other hand, there are hundreds of engineering shops up and down the country whose productive capacity could be vastly increased if better organisation were to displace the old rule-of-thumb method, or reliance on outstanding personalities.

The authors are of opinion, however, that these reforms will have to be introduced gradually and that the "extremist" reformers will gain no sympathy or success. Above all, beware of the professional business organiser.

It is with the object of showing a method which could be applied in part, or in the whole, according to the needs of the case, that the present paper was prepared. Therefore, do not make the mistake of starting with too ambitious a scheme. Decide on broad and sound principles to be followed first, and let the rest grow gradually.

The ideal system provides for the loss of any member of the clerical staff and the substitution of another, with the absolute minimum of effort on the part of either the management or the new member. In other words no subordinate should be indispensable.

Turning again to the key plan (Fig. 1), the main routine to be followed in respect to an order can now be noted. In this plan it is impossible, without destroying its lucidity, to show the incidental routine, so the main departments are shown separately in full detail. Nevertheless, it will be found that these detailed sub-plans all dovetail into one-another accurately. All this departmental information

can be further supplemented by the publication of a "Works Bible," which should preferably be arranged on the loose-leaf principle, as under the varying conditions of to-day amendments and improvements of the original scheme are sure to take place.

*(To be continued.)*

## THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.

### A PROGRAMME FOR THE FUTURE.

THE half-yearly meeting of the Manchester branch of the above Association was held on Saturday afternoon, the 9th inst., at 3-30 p.m., in the Association Hall, Mount Street. The platform was occupied by representatives forming the central committee of the Manchester area, Mr. Rostron presiding over the meeting. Among the officials present were Mr. Blair, general secretary, Mr. Jolley, secretary of the Manchester branch, Mr. Kay, the branch treasurer, and Mr. Roberts, chairman of the technical section. The Manchester branch, which has a membership of about one thousand, representing most of the great engineering firms in the Manchester area, embraces a somewhat extensive field, namely, from Preston to Crewe, and Warrington to the Yorkshire border. Some five hundred of the senior members of the Association were present, and a number of interesting speeches and reports were delivered by the various representatives.

The Chairman, Mr. Rostron, opened the meeting in a speech dealing with the purpose and scope of the Association, not omitting to interpose a touch of humour, and concluding by an exhortation to all members present to do their utmost to ensure the Association becoming of intellectual, social, and material benefit to all connected with it. Mr. Kay, the treasurer, briefly spoke on the financial and business side of the organisation, and touched upon the possible changes in the methods of working which would become necessary as the Association grew in membership. Mr. Roberts made a report of the work done by the technical section, the object of which is to develop an increased interest in the technical side of the profession, by a series of lectures given by the various members, the issue of technical literature, and the possible formation of a library. Under the head of suitable subjects for the various papers which might be given, Mr. Roberts outlined an attractive syllabus, which was calculated to inspire and encourage the zeal of any members possessing literary tastes. Mr. Blair, of Glasgow, to whom a very cordial reception was given, reported upon the larger activities in the movement, and at the conclusion of his remarks spoke of the pleasure which it gave him to be present at so influential a meeting, and to listen to the speeches delivered by the various representatives. Mr. Jolley touched upon the earlier organisations of the Manchester Branch of the Association, and of the possibilities it held. Enlarging upon the indispensability of engineering designers and draughtsmen generally, he expressed his conviction that the movement would have a strong and elevating influence in the profession. Following upon an interesting discussion of the various points at issue, a hearty vote of thanks was proposed to Mr. Blair for his visit, by Mr. Arnold, of Bolton, seconded by Mr. Youngmark, of Preston. The meeting terminated shortly before six o'clock, the members present being unanimous in expressing their views as to its success and interest.

## METAL MELTING AS PRACTISED AT THE ROYAL MINT.

By W. J. HOCKING.

(*Concluded from page 333.*)

(4) *Cost of Labour.*—Coke fuel necessitates considerable handling; gaseous fuel is delivered at the furnace without manual labour. During the period 1905-9, the average annual consumption of coke was 535 tons. Two men were employed in each melting house to transfer the coke from the store to the furnaces as required and to remove the ashes and clinker. This labour, as well as that of periodically feeding the furnaces, was abolished with the introduction of gas fuel. The coke store, which was 37 ft. by 12 ft., was no longer required for this purpose, and this valuable floor space was embodied in the main furnace room. Ashes and clinker were ground and washed for the recovery of the precious metals. With gas fuel the grinding and washing is confined to crucibles and furnace linings, and the bulk for treatment is considerably reduced in consequence. The weight of the grindings for each 100 tons of gold and silver melted under the two systems is estimated to be as follows:—

| | Gold. | Silver. |
|---|---|---|
| With coke fuel | 4·3 tons | 3 tons. |
| With gaseous fuel | 1·3 ,, | 0·5 ,, |

Viewing the staff as a whole, the number of men required for a given out-turn of coinage bars was reduced by the change of practice at the rate of about 20 per cent.

| | 1905-9. | 1911-16. |
|---|---|---|
| Average annual melt | 967 tons | 1,980 tons |
| Average number of men employed | 16·2 men | 27 men |
| Average number of men per 100 tons melted | 1·68 ,, | 1·36 ,, |
| Rate of reduction of labour | .. | 19 per cent. |

A comparison of the actual expenditure for the two calendar years 1909 and 1913 was made under three headings, viz., fuel, crucibles, and wages, the money value of which can be most readily ascertained. The result showed a saving in the latter year of 22·8s. per ton, or 27·6 per cent of the total cost in 1909. This economy on the year's melt of 1,958 tons, at the average rate of 22·8s. per ton, amounted to £2,232. For this comparison, piecework wages which vary with the rate of output is excluded, and only standing wages which vary with the amount of labour required is stated.

The chief item of cost occurring with gaseous fuel, but not with coke, arises in the provision of power for the pressure blowers. This item, however, is a comparatively small one. In the large room the electric current supplied is at the rate of 2 B.T. units per furnace-hour. The all-round cost for power is estimated to be at a rate not exceeding 2s. per ton melted, taking the current at 2d. per unit. This item has not been included in the foregoing tables of costs, as it is considered that sundry minor economies effected under the new system balance this additional outlay.

In connection with the general subject of costs, it may be of interest to state the initial outlay made in providing the new buildings with the plant specially required for melting with gas. The cost of the motors and blowers, the four 1,000-light meters, the pipes and connections for the gas and air services and the burners with their accessories, was £1,984. The capacity of this melting plant under ordinary conditions is represented by an output of about 2,000 tons annually.

| Year. | Weight of Metal Melted. | Annual Expenditure. | | | | Rate of Cost per Ton Melted. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fuel. | Crucibles, &c. | Wages. | Total. | Fuel. | Crucibles, &c. | Wages. | Total. |
| | Tons. | £ | £ | £ | £ | s. | s. | s. | s. |
| 1909......... | 1,198 | 1,455 | 2,544 | 939 | 4,938 | 24·5 | 42·4 | 15·7 | 82·4 |
| 1913......... | 1,958 | 2,162 | 2,613 | 1,061 | 5,836 | 22·1 | 26·7 | 10·8 | 59·6 |

With reference to the foregoing statistics, it might remove possible misapprehension to state that the figures are compiled from the working accounts of the Department, and no allowance has been made for such delays and accidents as have occurred in the routine of work during the periods under review. This feature should be borne in mind in comparing the results shown for the last five years with those of special test runs frequently quoted by furnace manufacturers. In point of fact, the weight of the metal which passed tthrough the crucibles is understated in the above returns. No record is made of the weight of the spillings, filings, rough ends, and faulty bars which occur more or less with each pouring, and are re-melted in the course of the day's work. The proportion re-melted but not noted in the books varies with the several metals, and also with the quality of the ingots, but the average weight melted twice on the same day is estimated to be between 2 and 3 per cent of the total amount given to melt. Therefore, to ascertain more approximately the gross amount melted with the gas recorded at the meters, the weight stated above for 1911-16 should be increased at the rate of (say) 2½ per cent, that is, from 9,899 tons to 10,146 tons.

### Recovery of Metal.

An important factor in Mint work is the adequate control of the precious metals given to melt. In an ordinary working day the amount of gold melted is more than three tons, and is worth nearly £400,000, and of silver about nine tons, which in coinage value is £80,000. Obviously, a satisfactory account of these values must be rendered at the close of the day. And the recovery of the metal given to work was a feature considered in choosing the form of furnace. It was ascertained by experiment that spillings of metal and splashes from the crucible were recoverable with comparative ease from a furnace with a closed bottom, while this form was more uniform in heating results than one with a removable bottom.

Larger deposits of metal in the furnace owing to fractured crucibles were also found to be recoverable. Occasionally a crack develops in the crucible when the metal is molten, and a certain amount runs into the furnace. This metal is allowed to cool after the crucible is drawn, when it forms a solid mass round the graphite stand. It is then possible to chip out the soft plumbago and withdraw the culôt of metal from the furnace.

The bottom of the furnace consists of a solid fire tile, 20 in. square and 2 in. thick, and at the junction of the lower course of brickwork and the tile a moulding of fireclay is introduced, rounding off the sharp corner. Consequently, the spillings and runners on cooling have their underside domed in shape and relieve readily. If the furnace is badly worn and the metal becomes keyed into the side, the lower course of brickwork is removed.

### Gold Melting House.

The furnaces for melting gold are similar in construction, but of smaller dimensions than those for melting silver and bronze. The room contains ten furnaces built in a single battery, and the internal measurements of the wellholes are 12 in. diameter and 21 in. deep. The melting capacity of each furnace is about 17,000 oz., or 529 kilos per working day of ten hours. As the general arrangements of the plant are similar to those in the larger room it is hardly necessary to specify the details.

The author has to thank Sir Thomas Elliott, the Deputy Master of the Mint, for permission to communicate this paper to the Institute, and Sir Edward Rigg, the Superintendent of the Operative Department, for kindly reading the paper in MS. The drawings and photographs were prepared by the author's colleague, Mr. W. L. Whitaker, to whom his thanks are also due.

*(Concluded.)*

## EDITORIAL—*continued from page 341.*

### Confidence in Executives.

The lesson of confidence in their duly-elected executive, local or national, is one which requires careful consideration by the men. It is going to have a serious effect in the future, for the problems of industrial organisation which require to be adjusted and settled as the war proceeds, and immediately it ceases, are such as have never bulked so largely before. We say with all seriousness—and it applies to employers as well, for there are among these, types of men who cannot in the least be termed broad-minded or tolerant—that the men cannot be too careful in the selection of their representatives for the conduct of negotiations which will be certain to arise. These representatives should be men of wide outlook, capable of seeing the true bearings of industrial problems from a point of view as detached as possible from the narrower platform of mere trade unionism. We say mere trade unionism in no offensive sense, but rather with a knowledge of the facts—true in every phase of life—that continuous close attention to a particular phase of a subject is liable to blind one's view to other factors which are quite as important to a true perspective of any problem, and to a just estimate of what is best to arrive at a reasonable settlement. This is only applying to the relations men have with one another in the shape of employers and employed the very principles which the successful designing engineer brings to bear upon the materials at his hand in producing a successful machine.

We ourselves believe in ideals. We hope we always shall. We have gone through the mill in shop practice in our early days, because we had to, and we are the last to forget that we did. We certainly do not wish to forget. But the fact that we so laboured, while not diminishing our ideals, gives us experience to appreciate the problems requiring to be solved in industrial organisation. As we have said, the future problems are great. They can be solved amicably only by broadness of outlook, by intelligent appreciation of the whole of the factors, never by the narrowness exhibited in recent disputes.

# THE APPLICATION OF COAL GAS TO INDUSTRY IN WAR TIME: ITS NATIONAL IMPORTANCE.

By Horace M. Thornton, M.I.Mech.E.

*(Continued from page 328.)*

## The National Importance of the By-Products.

Apart from its importance as a lighting, heating, and cooking fuel, as I have endeavoured to describe to-day, gas possesses other and not less valuable properties of great worth in peace times, but essential in time of war. I refer, of course, to the by-products—coke, tar, sulphate of ammonia, cresote, carbolic and cresylic acids, benzene and toluene, certain of which contribute to the making of explosives, such as trinitrotoluol. Of these last, which in this war are vital to our preservation as a nation, the gas industry is providing a worthy proportion of the output in this country. Reluctantly, I must withhold the actual figures; but the full story of the patriotic endeavours of the gas undertakings in their ready response to the request of the High Explosives Supplies Detpartment at the Ministry of Munitions will be told one day when the war is over.

Further, there has to be considered the conservation of one of our greatest assets, our stock of unmined coal. Professor Brame, the successor of Professor B. B. Lewes in the Chair of Chemistry at the Royal Naval College, Greenwich, estimates the coal reserves as follows:—

| | Millions of tons. |
|---|---|
| United Kingdom ... ... ... | 186,153 |
| Germany ... ... ... ... | 415,794 |
| Russia ... ... ... ... | 59,079 |
| France ... ... ... ... | 16,207 |
| Belgium ... ... ... ... | 10,803 |

He further deduces, from our present rate of coal production, that we are exhausting our supplies at a far higher rate, proportionate to our stock, than our nearest commercial rivals. The Royal Commission on Coal, as far back as 1871 contempted the time when we, whose industrial greatness has largely been founded on our abundant and easily-obtained coal supplies, shall actually have become importers of coal. The statistics issued by the International Geological Congress in 1913 revealed that Great Britain only possesses about one-fortieth and our whole Empire only one-fourth of the world's estimated coal reserves; while the United States, likely to be our chief competitor in the near future, holds more than half. The most economical use of our remaining supplies is, therefore, a very practical and urgent question, and to aid in the solution the gas industry offers an important contribution, and we welcome the formation of the Board of Fuel Research, appointed by a Committee of the Privy Council, and presided over by our Chairman of to-day, Sir G. T. Beilby, LL.D., F.R.S.

We are chiefly concerned to-day with the fuel consumption of the factories of the country. It has been estimated that some 70 million tons of coal are burnt per annum for industrial purposes. Now I do not suggest that the whole of this coal could be displaced by gas; but a large part of it undoubtedly could be. With what result? First, this huge total of coal consumed in factories, if carbonised in the retorts of gasworks, might be expected to produce about 840,000 million cubic feet of gas; and, as I have endeavoured to show, this immense volume of thermal energy utilised for industrial heating processes would produce much enhanced results compared with those to be obtained if the coal were burnt crudely.

With coal there is a large amount of waste of heat units in effecting its combustion, and in driving off those volatile constituents which are useless where high temperatures and pure incandescence are required and must be obtained. There is also waste of heat units up the chimney shaft and through stand-by requirements. There is waste of heat units every time a fire is recharged until once more favourable working conditions of the fire are realised.

Then we come to the by-products, and the picture strikingly demonstrates their variety and their number. Instead of these ascending the chimney and "wasting their foulness on the city air," if scientifically treated on the lines of modern practice, they are preserved for the service of man. The coal burnt annually in our factories, would, if carbonised, give us, in addition to the thermal value of the immense volume of gas mentioned, say, 35 million tons of a smokeless fuel—coke—of high calorific value, and suitable for innumerable uses. Since the war started a large advance has been made in its application to steam-raising in road traction.

Then the amount of coal mentioned would give approximately 700 million gallons of tar, the worth of which will be obvious. One of its many uses, of recent development, is for road-making; and the new roads in the military areas in France have used thousands upon thousands of barrels of tar from English gasworks. As one of its minor uses, I might mention that I was told recently that tar was the most suitable lubricant for steel-pressing work. The contact with the hot steel split the tar into its free oils, and it was giving great satisfaction, and was considerably cheaper than other lubricants.

Another valuable by-product of gas manufacture is sulphate of ammonia. From the 70 million tons of coal before referred to might be extracted about 825,000 tons of this excellent fertiliser. Its worth has been emphasised by the Board of Agriculture in its endeavours to cultivate home production of foods.

The increase in motor traffic and the consequent passing of the horse have largely deprived our farmers of a source of material of good manurial value. These are, however, days of intensive cultivation—days when the largest and most valuable product per acre of land is required, and artificial fertilisers are therefore more than ever increasingly necessary. Nitrate of soda is a valuable fertiliser in respect primarily of its quick action under favourable conditions, but with heavy rains it suffers the disadvantage that it is quickly washed out of the soil. It is imported, and it therefore helps to weigh in the balance against our exports. Sulphate of ammonia is, in normal times, cheaper per unit of nitrogen than nitrate of soda, and much more so now. To destroy such a rich fertiliser by the crude use of coal is emphatically not to the national advantage.

I have already referred briefly to the explosives derived from coal tar, to the motor spirit (benzol) that is recovered and of which it is estimated over 200 million gallons are lost per annum through the consumption of raw coal in our factories. I might continue and remind you of the dye, drug, chemical, photographic, and perfume industries dependent on the derivatives of coal-tar distillation.

An absorbing story, truly, is this wonderful recovery of such priceless commodities from the secondary products of coal-gas manufacture. What an impetus it provides for legislation to reduce the amount of coal burned in a raw

state! So vast are the possibilities that it is quite within the range of reason that gas may become the by-product and the present by-products the primary ones. The value of the products for which coal would be carbonised and tar distilled may, with the revelations of time and science, become so great as to enable the gas to be sold at an exceptionally low figure—so low that competition of any other fuel, including raw coal, would be impossible. The present position is that less than one-fifth of the coal extracted from our mines is treated for the recovery of by-products. This gives an idea of the field still awaiting investigation and development.

In addition to the direct loss in the by-products, which I have tried to explain, there is the loss to the nation by the employment of the labour, horse and other vehicles necessary for the distribution of coal, which, of course, contributes to the wear and tear of our roads. All of this will be detrimental to our productive capacity in the strenuous years ahead; and, therefore, the transfer of every possible pound of the crudely-used coal to a more scientific and economic usage is an imperative necessity.

So far, I have to-day again endeavoured to tell some part of the story of the service of gas in war time, inadequately, I fear, for the colossal nature of the subject renders it impossible for one individual to deal fully and justly with the whole. But, if I may assume for the moment the *rôle* of prophet, and you ask me as to the prospects of the future, I can only reply that in my considered judgment what has already been accomplished is but a small earnest of what may be expected. The great market for gas seems to me to stretch almost illimitably into every sphere of human life and activity. New functions for its use and new methods of application are being discovered daily, appliances for its consumption are being perfected, and mechanical handicaps are being removed, and its supremacy above all fuels is being gradually but surely recognised.

In the realm of domestic cooking, heating, and water-heating its sway is becoming universal. Possessing the advantages we have seen this afternoon, with its record of service in the hour of the nation's greatest need—with the knowledge of its value gained in a time of unprecedented stress and strain—can we doubt that in time, shorter in period perhaps than is at present apparent, gas will be equally supreme in the greater world of industry?

In conclusion, I would express my thanks to many engineering friends who have responded to my request for information on the subjects treated in this paper, and to the Richmond Gas Stove and Meter Co. Ltd., Warrington, for providing details of their gas furnaces.

*(To be continued.)*

## GAS ENGINES v. STEAM TURBINES FOR IRON AND STEEL WORKS.*

By Douglas L. Cooper.

The question as to which is the most economical method of converting waste gases into power for blowing the blastfurnaces and generating electricity, is one about which there is still much diversity of opinion, some manufacturers favouring turbo-blowers and turbo-electrical generators, others gas-blowing engines with either turbines or gas engines for generating electricity.

Perhaps the most satisfactory way of making a comparison is to consider a modern iron and steel works having four blastfurnaces each producing 1,250 tons of pig iron per week, or an aggregate of 5,000 tons a week for the four furnaces. From generally accepted data, 150,000 cubic feet of gas of a heat value of approximately 100 B.T.U. per cubic foot are evolved per ton of coke consumed in a blastfurnace, so that assuming 22 cwts. of coke are required per ton of iron smelted, the total gas availabe from the above plant would be 150,000 × 5,500 = 825,000,000 cubic feet per week, of which, say, 38 per cent would be required for heating the hot blast stoves, including loss, leaving 511,500,000 cubic feet per week available for other purposes. In conjunction with these furnaces, a coke-oven plant with a capacity for carbonising, say, 8,600 tons of coal per week would be required, which, based on a coke yield of 70 per cent, exclusive of breeze, would give 6,020 tons of coke per week (the consumption of the four furnaces, plus an excess of about 10 per cent), and since the modern coke oven using Durham coal liberates at least 10,000 cubic feet of gas per ton of coal carbonised with a heat value of, say, 480 B.T.U. per cubic foot, of which, say, 50 per cent may be relied upon for outside uses, there would also be available from this source

$$\frac{10{,}000 \times 8{,}600}{2} = 43{,}000{,}000 \text{ cub. ft. per week.}$$

The problem, therefore, which presents itself is how best to employ these resources so as to reduce to a minimum (or to render unnecessary) the provision of further fuel in the production of the finished steel. The hourly quantities of the available gases would be as follows:—Blastfurnace gas = 3,044,642 cubic feet per hour at 100 B.T.U. per cubic foot = 304,464,200 B.T.U. per hour. Coke-oven gas = 256,000 cubic feet per hour at 480 B.T.U. per cubic foot = 122,880,000 B.T.U. per hour. As blastfurnace gas is more suitable than coke-oven gas for use in internal-combustion engines, it will be better to reserve the coke-oven gas for use in steel-smelting and re-heating furnaces, either alone or mixed with blastfurnace gas.

For blowing each blastfurnace, 25,000 cubic feet of free air per minute against a pressure of 12 lbs. per square inch will be required, and assuming temperature of air suction to be 60 deg. Fah., this duty, if performed at 100 per cent efficiency, would necessitate:—

$$2{\cdot}5 \times 2{,}115 \left\{ \left(\frac{26{\cdot}7}{14{\cdot}7}\right)^{0{\cdot}291} - 1 \right\} \times \frac{521}{493} = 1{,}061 \text{ H.P.}$$

If turbo-blowers be adopted from which an average efficiency of, say, 70 per cent might be expected, units of 1,500 B.H.P. would have to be installed, whereas if gas engines with reciprocating blowers be adopted from which an average efficiency of at least 80 per cent would be obtained, units of 1,326 B.H.P. would be large enough. Although the author is of opinion that in the case of rotary blowers the load and use factor is considerably higher than with reciprocating blowers, yet for the purpose of this comparison he has assumed equality in this respect. So that, taking the combined load and use factor at 70 per cent, the average continuous power required would be 1,050 H.P. per furnace, or 4,200 H.P. for the four furnaces in the case of turbo-blowers, and 928 H.P. per furnace, or 3,712 H.P. for the four furnaces, in the case of gas engines.

Assuming a boiler pressure of 250 lbs. above atmosphere, 150 deg. Fah. superheat, a vacuum of 28 in. of mercury, and a feed-water temperature of 70 deg. Fah., the turbines would require 12 lbs. of steam per horse-power hour (which for this duty may be regarded as

* Paper read before the Cleveland Institution of Engineers, April 30th, 1917.

excellent practice. Calculating on a boiler efficiency of 55 per cent, when burning blastfurnace gas, the heat units required would be:—

$$\frac{(1,205\cdot8 - 38 + 150)}{0\cdot55} \times 12 = 28,752 \text{ B.T.U. per H.P.-hour,}$$

being equivalent to a thermal efficiency of 8·8 per cent, so that for the 4,200 H.P. required 4,200 × 28,752 = 120,758,400 B.T.U. per hour would be necessary. The usual guarantee for large gas engines is 1 H.P. hour per 10,000 B.T.U., which is equal to a thermal efficiency of 25·5 per cent, thus the heat consumption required for the 3,712 H.P. would be 3,712 × 10,000 = 37,120,000 B.T.U. per hour.

In addition to the blowing of the blastfurnaces approximately 30 kw. hours per ton of iron produced would be required for operating the auxiliary machinery in connection with the blastfurnace and coke-oven plants, which, based on a make of 5,000 tons per week

$$= \frac{5,000 \times 30}{168} = 892 \text{ kw.-hours per hour.}$$

If generated by turbo-electric alternators under boiler conditions as stated above, calculating on a steam consumption for the turbine of 15 lbs. of steam per kilowatt-hour, this power (892 kw. hours) would require:—

$$\frac{(1,205\cdot8 - 38 + 150) \times 892 \times 15}{0\cdot55} = 32,058,480 \text{ B.T.U. per hour.}$$

If generated by gas-driven alternators, the heat units required would be

$$\frac{892 \times 10,000}{0\cdot746} = 11,957,104 \text{ B.T.U. per hour.}$$

Turning now to the steel works. For the conversion into steel of the 5,000 tons per week of iron produced in the blastfurnaces, an open-hearth plant capable of dealing with this amount + say, 20/25 per cent of cold metals and oxides per week would be required. From this plant a yield of, say, 105 per cent on the 5,000 tons of iron charged from the blast-furnaces might be expected, *i.e.*, an average of 5,250 tons of ingots per week.

Blastfurnace and coke-oven gases cannot be substituted for producer gases in a direct proportion of one heat unit of the former gases replacing one heat unit of the latter, but as the calculations and experiments which go to prove this point have recently been very carefully considered by various authors, amongst others, Mr. Simmersbach in 1913, and Mr. Houbaer, of the Seraing Works, in Belgium, in the same year, it is not proposed to deal with these in the present paper; but, making a liberal estimate, viz., that 10,000 cubic feet of coke-oven gas are consumed per ton of ingots produced, there would be required for the open-hearth furnaces 5,250 × 10,000 = 52,500,000 cubic feet of gas per week, and as the coke-oven gas has a calorific value of 480 B.T.U. per cubic foot, the energy absorbed would be

$$\frac{52,500,000 \times 480}{168} = 150,000,000 \text{ B.T.U. per hour.}$$

In practice in Germany it has been found that better results are obtained in the open-hearth furnace from a mixture of blastfurnace and coke-oven gases (with a combined calorific value of from 180 B.T.U. to 230 B.T.U. per cubic foot) than from using coke-oven gas alone. Thus, if these gases are mixed in the proportion of 2·5 cubic feet of blastfurnace to 1 cubic foot of coke-oven gas, a mixture with a calorific value of 208 B.T.U. per cubic foot would be obtained. Of this mixture about 722,000 cubic feet per hour would be required, which in the above proportion would be, say, 516,000 cubic feet of blastfurnace and 206,000 cubic feet of coke-oven gas per hour.

From experiments at the Hoesch Works in Germany (at which the author was present) on a 60-ton Siemens open-hearth furnace, with coke-oven gas of a very much inferior quality to that produced from Durham coal, 10,000 cubic feet of gas per ton of ingots produced were required, but the author is satisfied that, given a suitably constructed furnace with ample area in the air chequers for pre-heating the extra amount of air which is required to give perfect combustion with coke-oven gas, very much better results may be obtained. The above-mentioned experiments took place in June, 1910, but on a subsequent visit in the summer of 1914 the author was informed that they were doing very much better as regards the heat units required per ton of steel produced than at his visit in June, 1910, but no actual figures were given. He, however, noticed that the blastfurnace gas was being pre-heated in the chequers as in the case of producer gas, and the coke-oven gas was passed by means of two burners into the top of the port end. Thus, based on the above calcuation, there would be required 516,000 cubic feet = 51,600,000 B.T.U. of blastfurnace, and 206,000 cubic feet = 98,880,000 B.T.U. of coke-oven gas per hour.

In addition to this, electrical power at the rate of, say, 12 kw.-hours per ton of ingots produced would be required for manipulating the auxiliary machinery in connection with this plant, which on the make assumed would be

$$\frac{12 \times 2,250}{142} = \text{say } 440 \text{ kw.-hours per hour.}$$

In the case of turbines requiring 15 lbs. of steam per kilowatt-hour, the heat units required would be

$$\frac{(1,205\cdot8 - 38 + 150) \times 440 \times 15}{0\cdot55} = 15,813,600 \text{ B.T.U.}$$

In gas engines of equal power there would be required

$$\frac{440 \times 10,000}{0\cdot746} = 5,898,123 \text{ B.T.U.}$$

Taking the rolling mill loss and waste at 20 per cent on the ton of ingots, *i.e.*, on the 5,250 tons, the mill output would be 4,200 tons per week, say half of this loss, *i.e.*, 525 tons, will be in the form of discard capable of being rolled down to light sections, shorts, or double sawn crops of a saleable value, etc., and the other half in the form of bloom ends, etc., which could be melted in electric furnaces for the manufacture of special steels, for which purpose a current consumption of about 800 units per ton of steel would be required

$$\frac{800 \times 525}{150} = 2,800 \text{ kw.-hours per hour,}$$

which, generated in turbines, would require

$$\frac{(1,205\cdot8 - 38 + 150) \times 15 \times 2,800}{0\cdot55} = 100,632,000 \text{ B.T.U.}$$

per hour, or, in gas engines,

$$\frac{2,800 \times 10,000}{0\cdot746} = 37,533,512 \text{ B.T.U. per hour.}$$

The average weekly output of finished steel from the rolling mills would, therefore, be 4,200 tons + 525 tons special electrical steel = 4,725 tons.

*(To be continued.)*

# Trade Items, Notes, &c.

The Engineering Department of the Illinois University.—Professor C. R. Richards, professor of mechanical engineering and head of the department since 1911, has been appointed dean of the College of Engineering and Director of the engineering experiment station of the University of Illinois to succeed Dr. W. F. M. Goss, who has resigned to become president of the Railway Car Manufacturers' Association of New York. Dean Richards is a graduate of Purdue University, 1890, and has been successively instructor in mechanical engineering, Colorado Agricultural College; and professor of practical mechanics, professor of mechanical engineering, and dean of the College of Engineering, University of Nebraska.

Concrete Roads after the War.—The council of the Roads Improvement Association, of which Prince Arthur of Connaught is president, at a meeting held in London recently, resolved to act upon a recommendation that investigations should be made forthwith into the claims of concrete roads. The council of the association is in possession of much interesting data, from America and elsewhere, concerning the economy and durability of concrete roads with reinforced concrete foundations. Instructions have now been given by the association for a report to be prepared and presented by Mr. H. Percy Boulnois, M.Inst.C.E., formerly city engineer of Liverpool and Deputy Chief Engineering Inspector to the Local Government Board.

Cotton Gears.—Only the highest quality of cotton is used in making gears of compressed cotton, and it must be thoroughly cleaned. It is received at the factory in the usual rolls as it comes from the roving frames. These are rewound on cylinders, and compressed by hydraulic pressure into blanks for the gear-cutting machines. The blanks are usually formed with an outer covering of steel, no metal bushing being used in the bore. The cotton filler is compressed under hydraulic pressure of several tons per square inch of side surface, and held in compression by the steel shrouds or side plates by threaded studs. In large gears having special hubs, economy of manufacture requires the use of a metal centre and a separate cotton rim. The blanks impregnated with oil are cut on the usual gear shapers or with rotary cutters.

On the Taxing of Industry.—In the course of an article on the fairness which is due to the industry of the nation, *The Iron Age*, New York, states that the framers of tax legislation have planned to get a large income for the Government by heavily taxing all war activities. They have failed, adds our contemporary, to give due weight to the large sacrifice of men which the war may impose on the present generation and to the high costs of all necessaries of life which will rule throughout the war—from both of which the generation following the war will be exempt. They have underestimated also the debt those who come after will owe the present generation for so colossal an undertaking on behalf of humanity. Thus, therefore, the plan to raise by taxes what might better be carried forward in large part in the form of loans. Strongly arguing against this plan is the certainty that the industries, if too heavily taxed, cannot prepare to meet the demands which will be made upon them after the war. They are prosperous now, but unjust taxation would curtail their prosperity. That fact is being appreciated in the threshing out of tax proposals in Congressional committees.

Hydraulic Power Control in Switzerland.—The text of a Federal law concerning the utilisation of water power in Switzerland appears in the official *Feuille Fédérate Suisse* (Berne) of December 27th last (says the *Board of Trade Journal*). The law lays down the principle of the general supervision by the Federal authorities of the utilisation of hydraulic power derived from public or private watercourses in Switzerland, leaving, as heretofore, to the cantonal and other local authorities the granting of concessions. The relative rights of the Federal, cantonal and local authorities, and of the concessionaires, are defined, and provision is made for protecting the interests of navigation, fishing, etc. It is provided that at least two-thirds of the directors of a concessionaire company must be Swiss citizens and domiciled in Switzerland, and that no transfer of the concession may be made without the consent of the conceding authority. The maximum period for a concession is fixed at 80 years. The *Feuille Fédérale* of April 25th contains the text of a circular sent by the Federal Council to the Cantonal Governments relative to the drawing up of local regulations to give effect to the above-mentioned law, ond fixing January 1st, 1918, as the date of its coming into operation.

Honours for Engineers.—His Majesty the King has been pleased to confer the following honours upon members of the engineering branch of the Navy:—Distinguished Service Order: Engineer Lieut.-Commander J. B. Pulliblank. Distinguished Service Cross: Chief Artificer Engineers H. E. Pope, J. W. Farrow and Henry Taylor; Artificer Engineer W. T. Hall. Distinguished Service Medal: Chief Engine-room Artificers J. H. Deacon, John Bryant, J. J. Williams, S. B. Mitchell, W. J. McCleery, W. S. Harrod, James Leighton, Neil Campbell, John Fish, C. W. Thomas, A. E. Jones, A. H. Taylor, T. W. Adamson, P. J. Beer and R. G. Ribbons; Engine-room Artificers H. J. Owen, R. W. Stewart, Herbert Dobson, W. O. Kennedy, W. C. Kingswell and H. A. Drury. Mentioned in Despatches: Engineer Commander W. B. Lakeman; Engineer Lieutenants J. B. Hyde and J. T. Barrett; Chief Artificer Engineer F. Smith; Artificer Engineer Andrew Moules; Chief Engine-room Artificers G. F. Redhead, Henry Bell, William Poole, Frederick Baynham, James Galloway, Philip Morrison, G. C. Stalkers, Henry Bradshaw, Nicholas Whitford, W. F. Barrow, H. J. Northey, Alexander Robb, J. M. Dent, Joseph Thompson and John Lightbound; Acting Chief Engine-room Artificer Frank Meachem; Engine-room Artificers James Edgar, Herbert McKay, F. G. Martin, Robert Cochran and D. L. Walmsley.

Electric Power in Industry.—The Electric Power Supply Committee, appointed by the Board of Trade, under the chairmanship of Mr. Huth Jackson, to consider what steps should be taken to ensure an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of such power for their development, have unanimously come to the following conclusions: 1. That the success of British industry after the war will depend upon the adoption of the most efficient methods and machinery, so as to reduce manufacturing costs as much as possible. 2. That a highly important element in reducing costs will be the general extension of the use of electric power supplied at the lowest possible price, and it is by largely increasing the amount of power used in industry that the average output per head, and as a consequence the wages of the worker, can be raised. 3. That the supply of electricity in a large number of small areas by separate authorities is incompatible with a technically sound system. 4. That the interconnection of existing electric supply stations recommended by the Board of Trade in their letter of May 25th, 1916, cannot alone meet the requirements of the situation. 5. That a comprehensive system for the generation of electricity, and where necessary reorganising its supply, should be established as soon as possible. It has been decided to invite representative associations throughout the country to give evidence before the Committee with regard to the best methods of giving effect to these conclusions.

Electric Arcs in Ether.—In a contribution to No. 4 of the "Archive for Mathematics, Astronomy and Physics," of Stockholm, 1916, A. Rönnholm describes some interesting experiments on the behaviour of arcs produced in ether between metal electrodes, in parallel to capacity-reactance circuits. It was found that for each resistance there was a certain current range, over which oscillations were produced and the arc could not be maintained. The peculiarities are best explained by reference to a diagram. Plotting the volts across the arc as ordinates against the currents, and drawing diverging lines from a point marking the line potential (220 volts) to different points on the abscissa (0·4 amperes to 2 amperes), we get a kind of fan of divergent outlines, and a belt across this fan, not of uniform breadth, but of fairly regular outline, would mark the range within which the current oscillated. This belt becomes wider with increasing capacity and narrower with increasing inductance; the greater the conductivity of the electrodes, the wider the region of oscillations, which was wide for copper and narrower for aluminium and still narrower for iron. Thermal relations evidently have a good deal to do with the phenomena; when the two electrodes were not of the same metal, the anode, getting hotter, was of greater importance than the kathode. The frequency of the oscillations did not appear to depend on the nature of the metal.

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon power engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

### THE ENGINE AND THE ENGINEER.

*To the Editor of "The Industrial Engineer."*

Sir,—No engineer expects a satisfactory output from an ill-designed machine; he either scraps it or improves it.

Every business man expects an adequate return on the money invested in his business.

Are you satisfied as an engineer with the design of the legislative machine, and with the quality of its output?

Are you satisfied as a business man with the return you get on your share of the money expended on its upkeep?

If you examine the legislative output of the last decade, you will notice that the bulk of it consists of measures such as the power and constitution of the House of Lords, the Welsh Church, Plural Voting, Home Rule, and kindred matters, which can in no way advance the interests of either manufacturers, traders, or workmen.

While industrial interests have not been entirely neglected, such measures as have been introduced have tended to destroy, rather than to promote, that cordial co-operation between employer and employed without which we cannot hope to regain our industrial supremacy.

Some attention, it is true, has been devoted to our fiscal policy which vitally affects producer, consumer, and purveyor; but the debates were conducted for the most part rather from a party standpoint than with any sincere desire to advance national and imperial interests.

Even now, while Parliament can find time to legislate on women's suffrage, proportional representation, and the Irish "settlement," the resolutions passed at the Paris Conference are kept in abeyance, with the result that manufacturers and merchants are kept in the dark as to how they will stand after the war, and cannot with any confidence embark on post-bellum projects.

Other matters which vitally affect our industries, such as industrial banking, satisfactory Consular representation, Empire trading, imperial, electrical, and shipping communication, and the like, have not received the attention which their importance deserves.

Manufacturers will therefore do well to adopt as their representative a candidate closely identified with the industries of the district; and since industrial efficiency is largely dependent on the skill and inventive faculty of engineers ,they would be wise to encourage the candidature of suitable members of that profession.

The House would gain by the presence in larger numbers of men whose outlook is essentially practical and constructive, even at the expense of a corresponding number of members of the legal profession, which is by comparison largely over-represented. The institutes of civil, mechanical, and electrical engineering might well use their powerful influence in this direction.

While the efficiency of the machine has steadily decreased, the cost of running it has increased in the same ratio, a result which any engineer would expect.

Its defects and the remedies which seem to be indicated are explained in a leaflet published by the Society for Upholding Political Honour, 56, Victoria Street, London, S.W. 1.

Of these remedies the most important are:—

The publication of the source, amount, and disposal of all moneys devoted to party objects.

The grant of honours only on the joint recommendation of both front benches, together with the publication of a full statement of the services rendered by the recipient to the State.

The payment by the ratepayers of election expenses and members' salaries (if salaries are to be paid).

The exaction from Parliamentary candidates of a pledge that they will vote in accordance with their convictions.

If no better plan can be devised, card voting by ballot on divisions, though not free from objection, would secure the proper representation of minorities and effectively protect members from coercion by the Whips.

There are fortunately in existence powerful organisations, bent on placing our industries on a firmer basis, but since their proposals must go through the legislative mill before they emerge as Acts of Parliament, the first step is to improve the machinery that fashions them.

The machine cannot mend itself; reforms can be brought about only by the pressure of public opinion, to which the professional party politician with the aid of the party funds will oppose a stout resistance.

All who desire to co-operate in eliminating the "party" grit, which clogs the wheels of the legislative machine, have now an opportunity of doing so by forming local branches in support of the Society for Upholding Political Honour.—Yours faithfully,

F. D. Fowler.

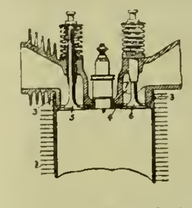
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

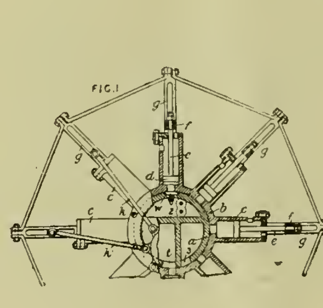
103,960.—Daimler Co. and A. E. Berriman, Daimler Works, Coventry.—Sept. 9th, 1916.—The cylinder barrel extends beyond the head 4, as shown at 3, and forms a receptacle for a valve-chest 7

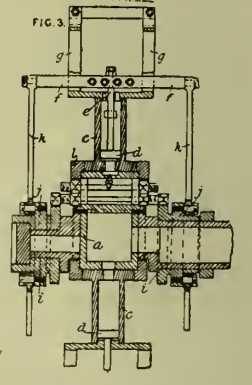


of aluminium, which may be secured by long bolts from the crank chamber. Cooling-ribs 9, either integral with the barrel or applied thereto, also extend beyond the head, which may form seatings for valves 5, 6.

### FLUID-PRESSURE ENGINES.

104,056.—W. H. Seddon, Vicarage, Painswick, Gloucestershire.—March 29th, 1916.—The engine is described as a two-stroke-cycle internal-combustion engine, but is suitable for other fluid pressure. The cylinders *c* are arranged radially or tangentially and



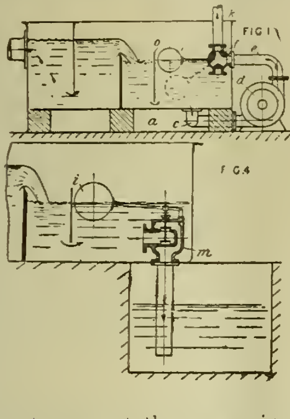


revolve around a partitioned member *a*, which acts as a valve supplying compressed air for scavenging through a port 3 and mixture through a port *t*. The pistons *d* act outwards. Their rods *e* are connected to crossheads *f*, which slide in guides *g* made in one with the cylinder covers, and which are connected by links *k* to eccentric sheaves *j* mounted upon eccentric members *i* adjacent to the port *a*. The sparking-plug 2 is carried in a recess *w* in the valve member *a*. The cylinder member *b* has an internally toothed member *l* secured thereto, which is geared to the eccentric sheaves to rotate them at the same speed as the cylinders. In a modification, the cylinders are provided with pistons having rigid rods carrying rollers which bear upon a stationary or geared eccentric member, or pivoted rods pivoted to a geared eccentric member rotating with the cylinders. The eccentric member may be connected by spokes to eccentric sheaves on either side of the valve member.

### BOILER-FEED SYSTEMS.

104,061.—J. E. Lea, 28, Deansgate, Manchester.—April 4th, 1916.—In a system in which water of condensation or boiler feed-water is measured by a V-notch or weir meter and then discharged from the receiving-tank to a storage tank or to the boilers, means are provided to prevent aeration of the water. A pump *d*, Fig. 1, draws water by the pipe *c* from the catch-box *a*, and delivers it

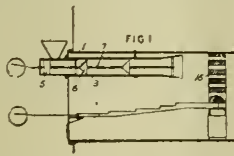
by the pipe *e* and three-way or Corliss valve *f*, either to the discharge pipe *k* or back to the catch-box. The valve *f* is controlled by the float *i* so as to maintain the water-level about 4 inches below the V-notch and thus prevent splashing and consequent




aeration, and also to prevent the uncovering of the pipe *c* and admission of air to the pump. As a further precaution, a baffle-plate *o* having openings at or near its lower corners may be provided. In a modification, Fig. 4, the water is discharged by gravity into a lower tank, and the outlet valve *m* is controlled by a float *i* to maintain a predetermined head in the catch-box.

## STEAM-GENERATOR FURNACES.

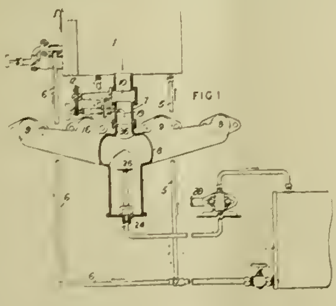
104,084.—W. H. NIELD, 275, Stockport Road, Cheadle Heath, Stockport, and W. MELLAND, 23, King Street, Manchester.—April 28th, 1916.—In a boiler furnace, the fuel is continuously and automatically fed through a coking-chamber in the upper part of the flue to the rear of the furnace, and is then returned to the front by a moving grate. The coking-chamber may be formed by a partition cutting off the upper part of the flue, or may consist, as shown, of a flared refractory tube or retort 3 supported by straps so that it can be turned to present a fresh surface to the




fire when necessary. Alternatively, the tube may be moved farther into the furnace as the exposed end is burnt. The fuel is supplied from a hopper 1 and is fed forward by a reciprocating rod 7 carrying a piston 5 and discs 6 or pivoted arms, or by a screw conveyer. The rod 7 or the conveyer shaft may be hollow for the supply of steam and for allowing the insertion of a poking-tool. The grate shown consists of reciprocating bars with steps increasing in length towards the front of the furnace, or an endless chain grate may be used. A perforated baffle 15 may be mounted above the bridge.

## INTERNAL-COMBUSTION ENGINES.

104,096.—J. G. A. KITCHEN, 7, Rose Bank, Scotforth, Lancaster, and I. H. STOREY, Loughrigg Brow, Ambleside, Westmorland.—May 19th, 1916.—The apparatus is of the kind described in Specification 10,345/13, in which vapour generated in a vaporiser 1 issues from a nozzle 19 in the air-pipe 7. The warming of the air before it mixes with the vapour is dispensed with, but the nozzle 19 is insulated from the air-pipe by a non-conductor of heat 36. Un-



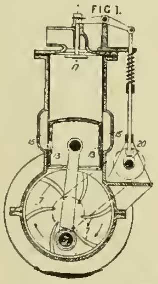

vaporised and condensed fuel is arrested by a plate 26 and falls into a sump 24, whence it is withdrawn and discharged into the reservoir 3 by a pump 29, which also serves to keep up the air pressure in the oil reservoir 3. The air valve 10 and the vapour valve 16 are geared together by adjustable spur gearing 12. The pipe 5 leads to the vapourising coil, and the pipe 6 to the burner. The branches 9 of the induction pipe 8 lead to four cylinders.

## INTERNAL-COMBUSTION ENGINES.

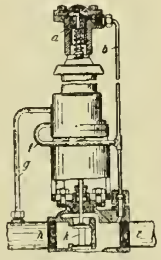
104,089.—SIR K. I. CROSSLEY and W. LE P. WEBB, Crossley Bros., Openshaw, Manchester.—May 5th, 1916.—The combustion chambers are water-jacketed; they are either oval, that is, with one end smaller than the other, or elliptical in longitudinal section, and either circular or elliptical in transverse section. The longitudinal axis is normal to the cylinder axis, and the air and exhaust valves are either parallel or inclined to each other and situated opposite the piston; or the exhaust valve may be at one end of the chamber. The fuel nozzles are at one or both ends of the longitudinal axis and may be on the piston side of it. The passage between the combustion chamber and cylinder may be restricted and entered by the piston on the end of an in-stroke. Specification 2,976/15 is referred to.

## INTERNAL-COMBUSTION ENGINES.

104,091.—J. H. W. GILL, The Windmill, Heacham, Norfolk.—May 9th, 1916.—To augment the charge drawn into the crank case of an engine using crank-case compression, fan blades 7 are secured to the crank-discs. Charges are drawn in through an orifice (not shown) controlled by a port in one end of the crank-shaft, and are delivered to the cylinder through passages 15 opening into the crank chamber through piston ports 13 fitted with wire-gauze to prevent back-firing. An exhaust valve 17 in the head of the cylinder is actuated by a longitudinally adjustable cam 20 which closes the valve at different points of the compression stroke to vary the compression at starting or during normal running. The cam shaft may be driven at one-half the speed of the crank-shaft, in which case a magneto driven therefrom supplies an igniting-current to two sparking-plugs which spark alternately. In a multicylinder engine, two crank-shafts may be geared together to run in opposite directions




Patent 104,091.



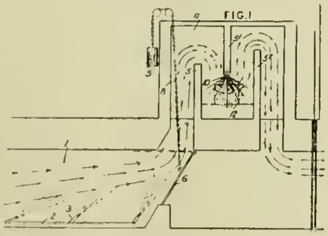
Patent 104,095.

## CONTROLLING FLUIDS UNDER PRESSURE.

104,095.—A. R. TRIST, 4, Lloyds Avenue, London.—May 11th, 1916.—Apparatus for controlling the pressure of fluid in a supply main *c* comprises a power device *a* connected by a pipe *b* to the main and adapted, when the pressure in the main exceeds a certain limit, to actuate the valve of a relay device, such as that described in Specification 14,255/13, and thus open a relief valve *k*. The exhaust of the relay valve is connected by a pipe *g* to the relief pipe *h*, and the admission side by a pipe *f* to the pipe *b*.

## CLEANING FLUES.

104,100.—J. P. LITTLE and A. U. MERRYLEES, 1, Eastwood Avenue, Shawlands, Glasgow.—May 31st, 1916.—In a flue provided with a system of steam jets for assisting the passage of gasses during the cleaning operation as described in Specification 1,246/14, a by-pass connection with baffles and a water-sprinkling device is provided, and the gases are passed through this connection

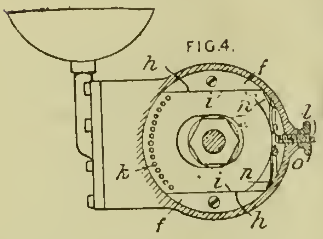


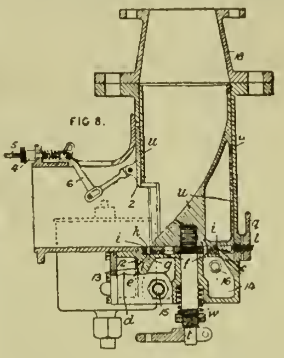

during the cleaning operation to remove the soot and flue dust from them. As shown, the flue 1 has a steam-pipe 2 with nozzles 3, and a damper 6, controlled by a chain 8 and weight 9, may be set to deflect the gases through a by-pass connection 4 fitted with baffles 5, 5¹, 5² and a sprinkler device 10 with a control valve. Soot, etc., is removed from the connexion 4 through an opening provided with a door 12.

## INTERNAL-COMBUSTION ENGINES.

104,101.—J. E. WILD, 59, Baxendale Street, Astley Bridge, and J. R. TOGNARELLI, 127, Deansgate, both in Bolton, Lancashire.—June 2nd, 1916. A rotatable air valve controls, simultaneously with the air, a number of fuel orifices, the openings through the whole of which may be independently adjusted to suit engines of different powers, and the air inlet of the rotatable valve is also adjustable independently by a sliding damper. The casing *a* of the carburettor, which contains the air valve *u*, has a shoulder *c* which supports a plate *f*, in which are formed fuel orifices *g* corresponding in number with passages *e* leading from the fuel

chamber *d*. The effective area of the orifices *g* is varied by a plate *i* sliding in a groove *h* in the plate *f*, loaded by a spring *n*, adjustible by nut *o*, *q* and screw *l*, and provided with holes *k* corresponding with the holes *g*. The air valve *u* is actuated through the spindle *t* and kept against the plates *f*, *i* by a spring *w*, and is cut away at its lower edge to control the fuel orifices. The air inlet of the valve *u* is adjusted by a sliding

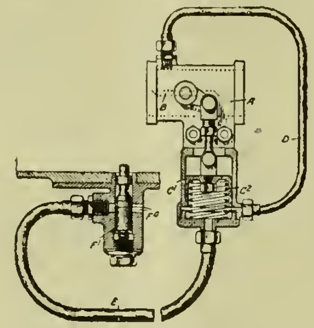



damper 2 actuated through a nut 4, screwed rod 5, and lever 6. The float chamber is detachably secured to the fuel chamber, which contains a filter of gauze 12 and felt 13. For fitting the carburettor to induction pipes of different sizes, the upper end of the casing *a* is fitted with an adapter 18. The lower portion 14 of the casing *a* is formed as a water jacket with connexions 15, 16. In a modified construction, the water jacket is dispensed with, and the damper 2 is actuated directly by a screwed rod.

### SPEED COVERNORS.

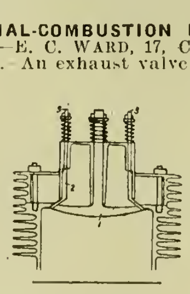
104,104.—W. H. Dorman and Co., Forcgate Street, and O. W. J. Watson, Camden Place, both in Stafford.—June 22nd, 1916.—A governor, particularly for internal-combustion engines, comprises a piston, etc. C1 connected to the throttle valve B and



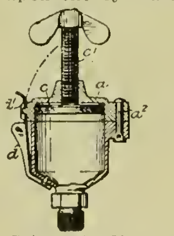
exposed on one side to the suction of the inlet pipe A through a conduit D. When the speed of the engine increases, a valve F1 is depressed by a centrifugal governor so as to admit atmospheric pressure through the ports F4 and a pipe E to the suction side of the piston C1, thus neutralising the suction effect and allowing a spring C2 to move the piston to close the throttle valve.

### INTERNAL-COMBUSTION ENGINES.

104,130.—E. C. Ward, 17, Clements Road, East Ham, Essex.—Oct. 3rd, 1916. An exhaust valve 2 which seats upon the cylinder head



Patent 104,130.



Patent 104,122.

is mounted concentrically with, and serves as a seating for, an inlet valve 1. Rods 5 carry springs for holding the exhaust valve in its closed position. By removing the holding-down bolts, the cylinder head may be rotated to grind the exhaust valve to its seat.

### GREASE-CUPS.

104,122.—G. N. Hall, 45, Barclay Road, Warley Woods, near Birmingham.—Sept. 14th, 1916. In a grease-cup having a plunger that is withdrawn into a recess in the cover for refilling, the cover *a* swings on a vertical or horizontal pivot *a*2 and is fastened by a spring catch *d*1; or the pivot may be dispensed with, two spring catches being used. The metal support of the piston leather *c* is strengthened by a flange. In the case of a piston operated by a spring, the spindle *c*1 is not screwed, but has feathers which, on being rotated to engage the outside of the cover, retain the piston in the recess. The device is applicable to a portable grease-gun having a handle and a flexible nozzle.

## INDEX TO ADVERTISERS.



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THE

# Industrial Engineer.

VOL. V.] JULY 21st, 1917. [No. 139.

## The Industrial Engineer.

*A PRACTICAL MAGAZINE FOR ENGINEERS AND POWER USERS.*

Published twice monthly, on the 8th and 22nd days, respectively.

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CONTENTS.



# EDITORIAL.

## COMMISSIONS ON LABOUR UNREST.

THERE are commissions and Royal Commissions. The latter are generally formulated to shelve rather awkward questions. At least that is the popular idea, for the fact that they often take years to investigate a subject and then report in a most unsatisfactory manner, is responsible for the lack of faith which is placed in their efforts and judgment. The latest Commission, or Commissions, to be more correct, are those which were charged with investigations into the causes of labour unrest, and as this unrest was more prevalent and widespread in the engineering industry, we make no apology for a reference to them in our columns. There is one pleasant and agreeable feature about these Commissions, and that is, they recognised the necessity of getting along with their investigations with speed and despatch. The main reason for this was undoubtedly due to the seriousness of the labour situation and the desire to appease the unrest at the earliest possible moment. As we go to press we learn that a summary of the reports of the various Commissions are in the hands of the War Cabinet, so that perhaps before these lines are printed the findings of the combined Commissions will be available to the public. This means that the work has been carried out with commendable rapidity —less than a month having been taken to complete it. We shall become real hustlers by the time the war is over and our American cousins will have to take a back seat.

It is reported that there is almost complete unanimity in the findings of the various Commissions, the first and foremost cause of unrest being declared to be the heavy increase in food prices and food profiteering. We have in these columns frequently urged the same causes, which are known and understood by anyone who takes the trouble to make even the slightest investigation. The Commissions, at any rate, have apparently put the seal of authority on what was generally alleged, and in consequence we may expect some remedial measures to be immediately taken, and with the same alacrity that the Commissions have done their work. We do not for one moment believe that engineering and other workers would in any way boggle at bearing a fair share of the inconveniences of war. Up to now they have borne more than a fair share, especially in the direction named.

The reports, we understand, also call attention to the irregularity of wages as between time and peace workers. This was highly necessary, as very considerable and justifiable soreness has arisen in this matter, particularly on the part of really skilled men in comparison with the men recently introduced into engineering works.

Other features with which the reports are said to deal is the exhibition of lack of confidence of the workers in the Government's attitude to labour, and the consequent growth of an unconstitutional form of trades unionism, and also the question of industrial fatigue due to the necessarily long hours which many of the men have worked. Another and important matter investigated was the time taken by the Government in looking into the causes of disputes and the long time taken in coming to a decision. It is said that there is general concurrence in finding that these allegations are true, and that the men had no other remedy than to strike. In some cases, as a result of this, settlements were effected in a few hours of matters which had been in dispute for a great many months, as many as twenty months.

The recommendations are that proper control of food supplies should be exercised and profiteering put down; that prices should be lowered by the Government; that hours of work should be reduced; wages adjusted in favour of the skilled as against unskilled labour; that fuller recognition should be given to trade union machinery and the rights and privileges of the unions should, without exception, be restored after the war. Increased

payments under the Workmen's Compensation Act are asked for, whilst better regulations regarding dilution of labour naturally form an important feature of the recommendations. This latter was fully to be expected after some of the recent disputes. The position of the men under the Military Service Act requires more clearly defining. A really pleasing feature of the report is said to be the desire to bring about closer co-operation between employers and workmen, so that disputes may be settled at their inception.

We believe that good will come of the report if the Government will seriously take to heart the findings of the Commission; if not, there is likely to be more serious trouble, which can be avoided by the exercise of common sense.

## Trade Items, Notes, &c.

Calcutta's Electricity Supply.—The consumption of electricity in Calcutta continues to increase month by month as compared with last year. The Calcutta Electric Supply Corporation Ltd. reports that the number of units sold to consumers during the four weeks ended April 27th, 1917, amounted to 2,174,348, compared with 1,917,213 units in the corresponding four weeks of 1916.

Institution of Electrical Engineers.—The Institution of Electrical Engineers has received the following cablegram from the American Institute of Electrical Engineers in response to a message expressing the Institution's appreciation of the American nation's entry into the war: "The American Institute of Electrical Engineers duly appreciates your message. We hope that the electrical engineers of Great Britain and of America working together in close co-operation can bring to a satisfactory conclusion the many electrical problems of the war."

Canadian Exhibition.—The Canadian National Exhibition will be held at Toronto this year from August 25th to September 10th. The United States, Mexico, the West Indies, and the United Kingdom are represented amongst the exhibitors. There will be a machinery hall and electrical building designed for heavy machinery and machinery in operation, and supply with ample steam power and shafting; a transportation building (for motor cars, etc.), and an industrial and process of manufacture building. Particulars from Dr. J. O. Orr, general manager, 36, King Street, East, Toronto.

French Industrial Reorganisation.—The *Journal Officiel* of May 3rd contains a draft of a law which will place at the disposal of the Ministry of Commerce, Industry and Posts, and Telegraphs an additional sum for restoring some of the industries in the invaded regions in the North. It is proposed to place a credit of 250,000,000 francs at the disposal of the Ministry for the purpose of buying tools, machinery, and materials which have been taken away or destroyed by the Germans. A special department of the Ministry has been constituted for carrying out this work, and 100,000,000 francs of the above sum will be voted in the Budget for the current year.

The Future of the Motor Omnibus.—At a recent meeting of the Birmingham District Power and Traction Co., the chairman (Mr. C. S. B. Hilton) raised a question of great interest to motor omnibus undertakings and the motor industry in general. Mr. Hilton pointed out that at present every motor omnibus in regular work contributes ½d. per mile, or between £50 or £60 per annum, in taxes. It was originally arranged that such taxes should be spent on road maintenance, but during the war that revenue had been diverted to other objects. Meanwhile individual road authorities were endeavouring by other means to compel omnibus owners to contribute to the repair and upkeep of the roads. He regarded that policy as very unsatisfactory from every point of view, and, if continued, it would undoubtedly have the effect of seriously crippling the development of motor transport in the public interest.

Diesel Engine Users' Association.—At the May meeting of the above Association a paper was read by the president, Mr. Geoffrey Porter, A.M.I.C.E., on "Tar Oil Fuel and Diesel Engines." The author gave a summary of some experiences of tar oils offered by distillers. In view of the present difficulty in obtaining sufficient supplies of residual petroleum oils, and the high prices ruling for fuel of the kind, the successful utilisation of tar oils of home production is of great consequence. After protracted negotiations an agreement has been concluded with the Inland Revenue Authorities to increase the rate of depreciation upon Diesel engines to 10 per cent per annum, with the proviso that this increase shall remain in force for three years after cessation of the war, when either party shall be at liberty to claim a revision. Having regard to the present high level of taxation, this increased allowance represents no inconsiderable saving to those companies and corporations entitled to the concession, and which is due to the efforts of the Diesel Engine Users' Association. This Association had previously been successful in bringing about a reduction in premiums charged for insurance against breakdowns.

Manufacture of Rifles for the United States Forces.—When war was declared (says *Arms and The Man*, U.S.A.), and it became certain that the national army would assume, numerically, great proportions, the ordnance experts of the army immediately realised that the output of Springfield rifles from the Springfield and Frankford arsenals would by no means meet the increased demand, or even keep pace with the recruiting. To meet just such an emergency, efforts have been made in Congress to secure the necessary appropriation for increasing the output of the standard arm. It was realised, however, that much time would be consumed in the manufacture of the special tools required and that there would still be a shortage of rifles. It was therefore the consensus of opinion that an emergency arm should be selected. At the present time thousands of the British Enfield, the Russian Nagant, and the French Lebel rifles are being turned out every day in the United States, together with some less modern types. That source of supply being immediately available, it has been decided to select one of these, chambered to take service ammunition, as the emergency rifle of the United States. Because a greater number of factories are equipped to manufacture the British Enfield and the output is greater than any other, it being possible within six months to produce between 6,000 and 11,000 a day, this arm will probably be adopted. Two patterns of the Enfield are now in use in the British Army. The newer so-called "Model 1914" will probably be the one chosen if the United States definitely decides to manufacture this arm. The rifle is considerably heavier than the Springfield, weighing 9 lbs. 5 ozs., the barrel being 26 in. long, against the Springfield weighing 8 lbs. 12 ozs., with a 24-in. barrel. In the British pattern—the kind now being manufactured in the United States—the calibre is 0·303 in., and the barrel is rifled with five grooves, with a pitch of one turn in 10 in. The Springfield has four grooves with the same pitch. The rifle is loaded by a charger holding five rounds. No cut-off is provided. The bottom of the magazine comes flush with the stock, and is removable for cleaning and repair.

The Corrosion of Cast Iron and its Bearing on the Electrolytic Theory of Corrosion.—The field of cast iron as regards its usefulness as a rust-resisting metal has been much neglected, and to-day remains almost unexplored. This, no doubt, is due in part to the fact that only in the last few years has the resistance of irons to corrosion been considered one of their important properties. The efforts to improve materials for structural and other purposes have been directed toward the production of a material having superior physical properties, such as tensile strength with a great reliability. This is the reason that cast iron, once extensively used for structural purposes, has been replaced by steel. However, for many other purposes cast iron is still used in enormous quantities in places exposed to corroding influences. Many instances are known where cast-iron objects have lasted many years, even centuries, and have remained in good condition when exposed to corrosive influences, and that when used underground cast iron is usually superior to other kinds of iron. According to the electrolytic theory of corrosion, cast iron, being less pure and more heterogeneous than steel or pure iron, should rust faster than either of these. Three pieces of these materials were exposed to rusting influences for seven months, then cleaned and weighed. Pure iron corroded least, cast iron 25 per cent more, and steel 100 per cent more. The electrolytic theory of corrosion does not explain these results. While it may be true that the initial rusting is largely electrolytic in character, other factors, such as the adherence of the rust and protection given thereby to the metal, come into operation and outweigh any electrolytic corrosion.—*Proceedings of the American Electrochemical Society.*

# MODERN STEAM TURBINES.

By J. HUMPHREY.

## Turbines v. Reciprocating Engines.

Nothing has had a more remarkable effect upon the general character of modern power stations than the introduction of the steam turbine. Not only has the turbine been the means of obtaining improved efficiency, but it has also enabled large power installations to be put down at comparatively low cost. The space required by a turbo-generator set, moreover, is much less than that required by a reciprocating set of corresponding output, and the amount of attention a turbine needs is small. From the point of view of maintenance cost a turbine is also much superior to a steam or internal-combustion engine. Where only small quantities of electric power have to be generated the turbine may not always be the best type of prime mover to employ, because it shows up to the best advantage when it has a fairly large capacity, but in large and medium-sized power stations reciprocating engines are now seldom, if ever, installed. It has, in fact, been possible in many cases greatly to increase the output of existing stations by removing the original reciprocating engines and installing turbines in their place. Besides these advantages a turbine has a very even turning moment, which makes it particularly suitable for driving alternators, especially those running in parallel on common bus-bars. Furthermore, the oil cost in a station equipped with turbines is remarkably small, because a turbine has no pistons or valves that have to be lubricated. For this reason the steam discharged by a turbine is perfectly clean, and may be used for heating and other purposes without difficulty.

## A Practical Example.

Before considering the principle of the turbine and the constructional details of modern types, attention may be directed to one notable example of how the capacity of an existing station in America has been increased by the employment of large turbines in place of the original reciprocating sets. In 1901 there were installed in the Seventy-Fourth Street station at the Interborough Rapid Transit Company of New York City eight 7,000 kilowatt reciprocating sets. These double horizontal cross-compounded engines were then considered representative of the highest development in prime movers for electric service. But while the steam consumption reached all expectations and the general running left little to be desired, four of these engines have been broken up and sold for scrap, and steam turbines have been installed in the space they occupied. The aggregate capacity of the four engines that have been scrapped was 28,000 kilowatts, whereas that of the three turbines occupying only the same floor space is 90,000 kilowatts. Hence the capacity of this part of the station has been increased by some 220 per cent without increasing the size of the building.

## Steam Consumption.

As regards economy, the guaranteed steam consumption of the reciprocating sets at normal full load and with a steam pressure of 150 lbs. per square inch and a vacuum of 26 inches was approximately 17·3 lbs. per kilowatt hour. At their full load of 30,000 kilowatts, however, the turbines when working at a pressure of 200 lbs. per square inch, a vacuum of 28 in. and a superheat of 120 deg. Fah. consume only 11·63 lbs. of steam per kilowatt hour. Assuming that the turbines are operated at three-fourths of the time at a load of 25,000 kilowatts, the annual saving in fuel alone for each unit amounts to over £40,000. This estimate is based upon coal costing 15s. per ton, and an average evaporation of 8·7 lbs. of water per pound of coal. It is difficult to make a direct comparison of the labour required by the two types of prime movers, but based upon the operation of other large stations it seems safe to say that the cost of labour per kilowatt of output when using turbines will be less than one-fourth of that required by the reciprocating engines. Of course, these turbines are of unusual size, and are much larger than any single unit so far installed in any station in this country, but at the same time, a large number of stations in Great Britain have been re-equipped with steam turbines with distinctly beneficial results. In every case where turbines have replaced reciprocating engines there has been a great increase in the station capacity, as well as marked improvement in economy

## Purchasing a Turbine.

When considering the question of purchasing a turbine, the engineer is confronted with considerations which did not present themselves a few years back, because at that time the Parsons' machine was practically the only type on the English market. To-day things are different, for British manufacturers now build turbines of various other kinds, and the problem of selecting the best for a specific purpose is not always an easy one, and particularly so when an engineer's experience has been confined to the reciprocating sets hitherto. In addition to Parsons' turbines there are Curtis, Rateau, and Zoelly turbines, all of which are good machines. All turbines, however, derive their power from changes in motion of the working fluid. Indirectly the fall in pressure through a turbine causes rotation because this fall in pressure generates velocity in the steam, and this velocity causes the turbine to rotate. Statical steam pressure, however, even though varying from the stop valve to the exhaust, cannot cause rotation, although it can, of course, produce end thrust. The steam on passing through a turbine has its direction and amount of motion altered, and in order that this may occur the blades must exert a pressure on the steam, and it is the corresponding reaction of the steam that causes the turbine to rotate. In all turbines there are two principal members, the member which causes the steam to acquire kinetic energy, and the member which utilises this kinetic energy and causes the shaft to rotate. Some turbines are called impulse turbines and others reaction turbines. In the former case the kinetic energy is generated in nozzles, and in the latter case in the blades themselves.

## The Parsons' Turbine.

Turbines are divided into stages, and in each stage a certain amount of the kinetic energy in the steam is utilised. In a reaction turbine such as a Parsons, the steam is passed alternatively through rings of fixed and moving blades, as shown in Fig. 1. The moving blades are attached to the periphery of a drum mounted so as to rotate between the blades which are attached to the inside of the turbine casing. The function of the fixed blades is to collect the steam after it has passed through a ring of rotating blades, and to redirect it on to the next row of moving blades. The rotary motion and torque of the drum are produced to a small extent by impulse due to expansion of the steam in the fixed blades, but mainly by the reaction of the steam as it leaves the moving blades. The main feature of this type of turbine is that the steam expands from the point of admission right through the rings of fixed and moving blades to the exhaust, and the generation of kinetic energy occurs both in the stationary and moving parts. The con-

tinuous expansion of the steam in passing through the turbine causes a difference in pressure to exist between the entrance and exit from the various blades, and this produces a considerable end thrust, which has to be compensated by means of balancing pistons. Obviously there is a certain amount of leakage between the tips of the blades and the turbine casing, and in order to reduce this leakage to a minimum the clearance is made as small as possible. Moreover, the pressure drop between the stop valve and exhaust end of the turbine is spread over a large number of blades. A pure reaction turbine therefore is necessarily long, and in the absence of proper precautions the casing is liable to sag and become distorted, as the result of differences in temperature. Before starting such turbines the casing should first be warmed up by allowing steam to pass into it, otherwise the blades in one or more stages may be stripped. It must be remembered that in a reaction turbine the steam is admitted to the blades at the inlet end at the full boiler pressure, while at the exhaust end the temperature is comparatively low. The importance of warming a reaction turbine up carefully before starting is therefore self-evident. The pure reaction turbine, however, has the advantage of a moderate peripheral speed, which enables the rotor blades to be fixed in a simple manner. All the details of a modern Parsons' turbine, and all operating and maintenance matters will be dealt with in a subsequent article. For the benefit of those who are not familiar with turbines, the next thing to be considered is how an impulse turbine differs from a reaction turbine.

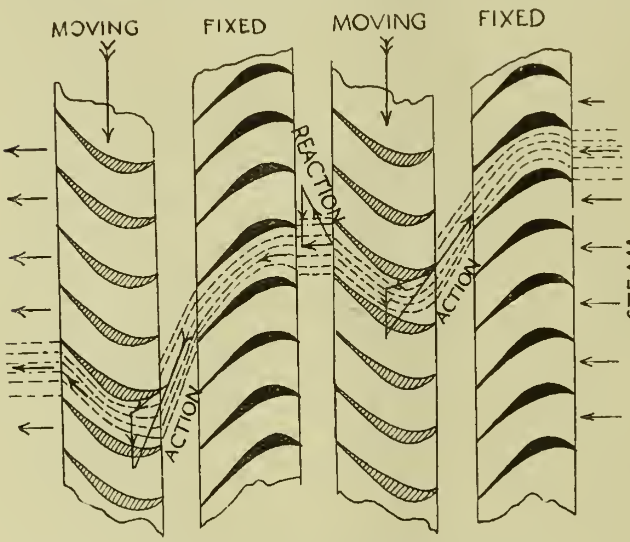



Fig. 1.—Blading for Reaction Turbine.

## Impulse and Reaction Turbines.

The steam in an impulse turbine is made to acquire kinetic energy by expanding it in stationary nozzles (see Fig. 2), and after leaving these nozzles it strikes the blades or buckets on a revolving wheel. The De Laval turbine is the simplest impulse turbine, because the steam from the nozzles impinges on only one wheel. But to extract the kinetic energy in the steam, with reasonable efficiency, on a single wheel involves a very high peripheral velocity, and unless wheels of very large diameter are employed gearing is necessary to reduce the high speed of rotation to practical limits. As a small unit, the De Laval impulse turbine has acquired a well-merited success, owing to careful design and workmanship, but for the large outputs which turbines are now called upon to develop, the single wheel construction is out of the question. The reason why a single-wheel impulse turbine must run at a very high speed is that the buckets on the wheel must bring the steam as nearly as possible to rest. In other words, the steam, after passing through the wheel, should have no kinetic energy. For the best efficiency the buckets should move at half the velocity of the wheel, and it is therefore easily seen why a single wheel must run at a very high speed. Steam at a pressure of 150 lbs. per square inch, for instance, expanded down to a 28-in. vacuum, can attain a velocity of 4,010 ft. per second, and it is not possible to construct a wheel that will run at half this speed. What is done, therefore, is to extract the kinetic energy in a series of moving wheels. In other words, the turbine is divided into velocity stages, the effects being to reduce the shaft speed. To illustrate the principle, the diagram (Fig. 3) has been drawn, from which it will be seen that after the steam has left the nozzles

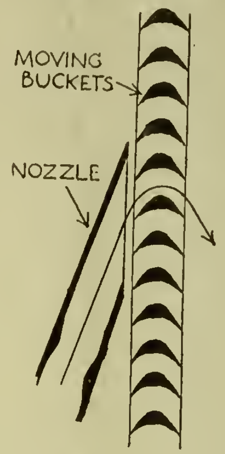



Fig. 2.—Impulse Wheel and Nozzle.


Fig. 3.—A Velocity Stage.

it strikes a row of moving blades. In these blades only a portion of the kinetic energy of the steam is utilised, and consequently the steam leaves these blades with a certain proportion of the kinetic left. It then passes into a set of fixed blades, which direct it on to a second set of moving blades, which extract more of the kinetic energy. It will be seen that the fixed blades are so arranged that the steam enters the second set of moving blades in exactly the same manner as it entered the first row. All the potential energy in the steam is converted into kinetic energy in the nozzles. In the nozzles, therefore, the pressure falls from the stop-valve pressure to that prevalent within the turbine casing. After the steam leaves the nozzles there is practically no tendency for it to expand further, consequently there is no appreciable end thrust or tendency for the steam to pass the blade clearance spaces. Exceptionally fine clearances are therefore unnecessary. The effect of extracting the kinetic energy in a number of running wheels instead of in a single wheel is obviously to reduce the running speed. A turbine built on these lines is said to be an impulse turbine with velocity stages. .

### Another Method.

There is, however, another method of sub-dividing the utilisation of the energy in the steam which can be combined with the velocity method just described. The turbine is divided into a number of pressure stages, as well as velocity stages, so that the total pressure reduction does not occur in a single set of nozzles. The arrangement can readily be understood by considering several velocity turbines connected in series, and instead of the total pressure drop occurring in the nozzle of the turbine connected to the boiler it is distributed over the nozzles of all the turbines. Imagine all these turbines assembled together in a single casing, and a clear idea is gained of what an impulse turbine with pressure stages is like. A relatively low velocity is imparted to the steam jets in each stage, which permits of a comparatively low speed of rotation of the wheels. Any degree of expansion, with its resulting steam velocity, can be dealt with in one pressure stage by providing a sufficient number of buckets or velocity stages to bring speed down to permissible limits, but the disadvantage of generating the kinetic energy in a single set of nozzles and utilising it in a number of velocity stages is that, if the practice is pushed too far, the steam friction losses are apt to be excessive. However, impulse turbines with pressure stages and other turbines will be dealt with fully in later articles. The main objects aimed at here have been to show clearly the essential differences between the pure reaction turbine and an impulse turbine, and to direct attention to the merits and demerits of each type.

*(To be continued.)*

## METAL MELTING.

By H. M. Thornton, M.I.Mech.E., and
Harold Hartley, M.Sc.

*(Concluded from page 371.)*

### Life of Pots.

A well-made graphite crucible is capable of withstanding very sudden temperature changes to an almost surprising extent. W. F. Downs* stated that he heated a small crucible to 1,400 deg. Cen. and plunged it into cold water, and repeated this treatment twelve times before any change could be detected in the note produced on tapping it with an iron bar; after repeating this treatment twenty times the note was practically gone. He makes the further statement that in actual commercial use for melting purposes a crucible has been known to stand from 80 to 100 charges in melting copper or a similar metal. This view is largely endorsed by F. Cirkel in his monograph on graphite. The latter says: "They stand in the manufacture of brass from 35 to 45 melts, when clay crucibles only stand from 4 to 6 melts. The very best crucibles made of the very best quality crystalline graphite can stand from 50 to 60 and even 70 heats of brass, a crucible made of amorphous or dense graphite will only stand from 6 to 8 heats. After every heat attention must be given to the removal of slag."

These statements refer to coke-fired furnaces, and although many melters only claim about 30 melts per pot it is an indication at least that, given favourable conditions, much better results are obtainable. The care adopted in the use of a crucible, and especially during the initial melt, is of outstanding importance. Barton states† that in making cartridge brass the average life of a pot (200 lb. size) is 25 heats, but is much shortened by ill-fitting tongs, excess of fluxes, "soaking" in the furnace, excessive furnace temperatures, wet or sulphurous fuel, and carelessness in stirring and handling.

Gillett† emphasises the importance of using properly fitting tongs, and appears to prefer the "Grab" to the "Pinch" type. He draws attention to the danger of wedging the crucible full of cold ingots or scrap, which on heating expand more than the pot and may cause splitting. In coke furnaces he says crucibles may be badly injured mechanically by carlelessness in poking the fire or in knocking off slag and clinkers. Excessive temperature changes of the pot should be avoided; if the best results are to be obtained they should not be allowed to cool too much between melts.

It is often stated to be noteworthy that the best results with regard to pot life are obtained in the brass-rolling trade, and this is attributed to the fact that those users have available and employ a good means of drying their pots prior to use; the pots being stored on top of the heat treatment furnaces, where they are kept dry. Probably all users take care to dry their crucibles, but it is doubtful whether the same attention is paid to the annealing—gentle heating up to a red heat before charging for the first melt. A little trouble taken at this stage will be well repaid later. Even though the preparation of crucibles may have been sufficient to avoid a "bumped" pot, the danger of the formation of small hair cracks in the pot has to be avoided if the best results are to be obtained. After the first melt has been executed satisfactorily, the crucible would appear to be capable of withstanding drastic heat treatment. It is not in our opinion, however, desirable to take liberties at any time, and we would advise always gentle heat treatment during the first melt of the day, as although the pot may appear to be unaffected by heating it up very rapidly there is always a danger of forming hair cracks.

In a gas-fired furnace the abrasive action of the solid fuel is eliminated, the direction of flow of the gas stream is under better control, the sulphur content of the fuel is very small (about 30 grains per 100 cubic feet), there is no fire to poke, and clinkers have not to be removed from the outside of the pot, so that it is not surprising

* *Iron Age*, May 24, 1900, p. 5.

† *Loc. cit.*

† *Loc. cit.*

that long pot lives can be obtained, especially in the absence of fluxes or with a flux which does not attack the crucible walls viciously. In a gas-fired furnace doing 5 or 6 melts a day no difficulty should be found in obtaining 45 to 50 melts out of a 70-lb. pot, thus comparing very favourably with the coke-fired furnaces. When a furnace is run full time doing 15 to 20 melts per day, and with a gas-fired furnace this is obtainable, a considerable increase in the number of melts per pot results. If the use of a flux does not determine the length of life of a pot, we should expect a 50 per cent increase in the pot life when a gas-fired furnace is substituted for one coke-fired—provided, of course, that the melter shows a reasonable amount of care in handling and loading the crucible.

### Increased Output.

On the basis of the figures given for brass melting, it follows that the average time for the actual melting operation is, for 12 melts of 68 lbs. each, 39 minutes, and for 15 melts 37 minutes, making no allowance for the time required to pour. Under similar conditions 55 minutes would probably represent an average for many coke-fired furnaces. With the gas-fired furnace cited above, the average time for melting can be decreased by 3 to 5 minutes by working at a higher consumption without a decrease in the thermal efficiency of the appliance. To claim a saving of time for melting of 25 per cent with a gas-fired furnace, against ordinary practice with a solid fuel furnace, in the melting of brass would not be excessive.

In conclusion, we wish to state that the results for gas consumptions which we have quoted have all been obtained in the works of the Richmond Gas Stove and Meter Co. by members of their staff, and are not to be regarded as representing "works practice," as ordinarily understood, by which the furnace is debited with the mistakes of the melter. On the other hand, the work has been carried out under such conditions that it would not be unreasonable to expect others in charge of the furnaces to obtain results of the same order. Once the furnace is set going the only duty devolving on the melter is to see that he keeps as much metal in the pot as possible and ensures that there shall be an ample, although not excessive, supply of metal in the pre-heating chamber; the charges there should be arranged, of course, so that the metal just before it is transferred to the crucible is in the hottest portion of the chamber. Above all, avoid the waste of time; if the gas consumption is about 3 cubic feet per hour per lb. of brass in the charge to be melted, or even more, it will be obvious that ten minutes wasted means that the average consumption for that particular melt is up by 0·5 cubic feet per lb., not to mention the possibility of an increased zinc loss, especially in the later stages of the process.

For obvious reasons more constant supervision is desirable in brass melting than in the longer processes of melting copper or cupro-nickel.

Probably the manufacturer will be served well if he arranges a bonus for low consumption on the basis of the output of castings, as in that way he provides a certain amount of protection against cold metal being supplied.

The authors wish to acknowledge the facilities given by the Richmond Co., Warrington, and the assistance of their Research Department in the compilation of many of the particulars given in this paper.

## APPENDIX.

### Description of Furnace.

The metal melting referred to in this communication has all been carried out in a Richmond 70-lbs. crucible furnace of the preheating type. The gas and air mixture is admitted through a suitable blast burner and the lower portion of the combustion chamber, and is burnt in the annulus between the crucible and the furnace wall. The gases, after travelling around the pot, are directed through the metal-preheating chamber, and then pass on to the air pipes and finally to the flue. This arrangement enables a high degree of pre-heat of the metal to be obtained.

The top of the metal chamber is on a level with the top of the pot chamber and is closed by a pair of lids. With this construction the operator has not to lift his metal above the foundry floor level, and the transference of preheated material to the crucible is done with ease.

The lower portion of the wall of the combustion chamber is constructed of suitably-shaped blocks of a specially refractory nature to enable greater resistance to be offered to the combined action of high temperatures and spilt metal. The bottom of the chamber can be removed simply for the recovery of spilt metal.

*(Concluded.)*

## WORKS ORGANISATION.

By A. W. Reeves and Cecil Kimber.

*(Continued from page 368.)*

### The "Preparation" and "Planning" Departments.

The preparation for actual production in the Works, see Fig. 12, is done by various departments, all under the direct supervision of the Production Engineer, the series of sub-departments being sometimes known as a Planning Department. Tracing the main routine of our plan, it will be seen that the sole link between the Executive Offices and the Works is the Schedule Department, which issues the authority to the latter to produce. This authority can be traced downwards in ever-widening branches similar to the genealogical trees familiar to history. The origination is, of course, the actual Sales Order, made out to cover the complete job. This Sales Order is then split up by the Schedule Department after consultation with the Chief Engineer, from a manufacturing point of view, and the Secretary, from a cost point of view, into a number of production Orders. These are the only authority for the Shop to begin manufacturing, and nothing must be started until they are issued, or costing errors are immediately perpetrated. The Production Orders are in their turn split up into Works Orders, covering each component part and in quantities such as will not necessitate the Works Order being "open" for more than a limited period. The Works Orders in their turn are split up into Job Cards, of which one is issued for every operator or machine engaged on that particular work.

Put briefly, the scope of each Order is as follows:—

> The Sales Order is merely a standardised copy of the customer's order to the Works as a whole to produce a definite amount of work.
>
> The Production Order is the order to the Shop.
>
> The Works Order is the order to the foreman.
>
> The Job Card is the order to the man.

In the same manner that the main Sales Order was divided, then sub-divided, and again sub-divided, so, when

the work is completed, must all these sub-orders be returned step by step, in the same manner in which they were given out. In the scheme under discussion, it is now proposed to show how this is done.

We begin at the Schedule Department, which issues to the Progress Clerk (*via* the Production Engineer) the Production Order, the Material Lists, and one set of Shop Prints, whilst, simultaneously, another set of Shop Prints goes to the Tool Designer. The Progress Clerk splits up each Production Order and makes out the necessary number

Production Order No. ....................

Piece Name ............................

Component of ..........................

**PROCESS SHEET**

**No. 1.**

(Numbered upwards in triplicate.)

Drawing No. ..........................

No. Off per Set .......................

Material ..............................

Date ..................................

| Operation No. | Operations. | Tools. | Jig No. | Gauge No. | Machine to use. | Remarks. |
|---|---|---|---|---|---|---|
| | | | | | | |

*The routine instructions on the respective Forms are:*

1. Process Fixer.—Make this form out in triplicate, but add additional spare copies if more than one mounted copy is issued to shop. However many extra copies are issued, all must bear same number. File one copy. Issue remainder to Foreman. All mounted except Pink Copy for Foreman's File.
2. Foreman.—File this Copy in numerical sequence in permanent special binder provided. Issue mounted Blue Copy or copies to Operator with working drawings. Return all copies on completion of Contract.
3. Operator's Copy.—This should be mounted and issued with working drawings.
4. Extra Operator's Copy.—This should bear same number as original Process Sheet in Office File and be issued with working drawings.

Fig. 6.—Process Sheet in triplicate for issue to Foremen with operation instructions. Note routine instructions on each copy. Also extra copies unnumbered for issue to additional operators as required.

**PROGRESS LEDGER.**

Production Order No. ........................ Date ........................................

Particulars.............................................. Quantity ..................................

Delivery Required .............................................................................

| Works Order No. | Date. | Quantity for. | Voucher Nos. | Date. | Material for. | Date W.O. issued to Shop. | Date returned completed. | Quantity good. | Quantity bad. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

N.B.—No Works Order should cover more than Six days' work in the Shop. If not returned within a week from date of issue, follow up. If original W. O. lost, do *not* issue another one with a fresh number. Make out the special replacement order from copy in Progress File and quote original number. Sub Works Orders must be the only shop orders to cover scrap and must only be issued by special sanction of C. E. Report to Chief Engineer all Production Orders requiring issue of Sub-W.O.'s to cover scrap.

Fig. 7.—Page from Progress Ledger.

.................. **STORES please receive as under. A** ..............

Ex PRODUCTION ORDER No..................Date..................

| Dept. | Quantity. | Description. | Part No. | Cwt. | Qrs. | Lbs. | Rate. | £ | s. d. | Folio. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

Foreman's Signature.........................................

Fig. 8.—Specimen "Inwards" Voucher (pink) accompanying all material passed *into* Stores.

....................**STORES please supply as under. F**..............

For PRODUCTION ORDER No. ...............Date.................

| Bin No. | Quantity. | Description. | Part No. | Cwt. | Qrs. | Lbs. | Rate. | £ | s. | d. | Folio. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

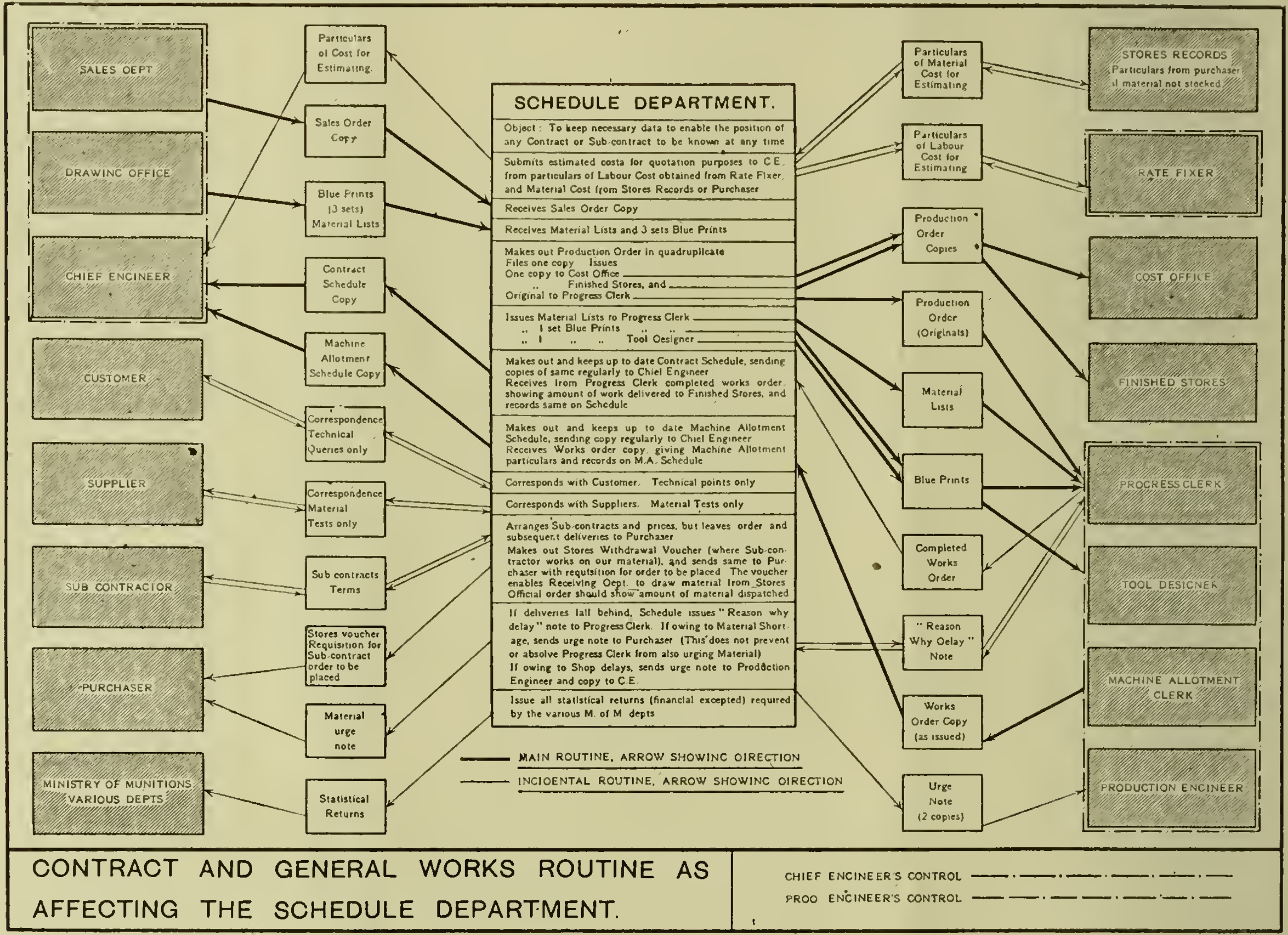
Foreman's Signature..........................................

Fig. 9.—Specimen "Outwards" Voucher (white) for drawing material *from* Stores.

of Works Orders, one for each component. The Works Orders are in triplicate: two tissue copies and one card, Fig. 5.

The Progress Clerk then checks over the Material List, sends an enquiry to the Stores Record Office and requisitions on the Order Department any goods not stocked. He makes out the Stores Withdrawal Vouchers, which cover only the quantity of material required for the particular Works Order. He enters all particulars in the Progress Ledger and files one copy of the Works Order in the "live" progress file, and passes on the remaining two copies, the Shop Prints and the Stores Vouchers, to the Process Clerk. The latter having made out the Process Sheet which is department foreman concerned. The foreman then allots his men to the various machines specified on the order, first drawing from the Clock Office the necessary number of Job Cards, one for each man. He issues to each man the Tool Withdrawal Card or Cards covering the particular tools required for the job, as arranged by the Tool Designer, and as specified on the Process Sheet. He also issues the Stores Withdrawal Vouchers, enabling the necessary material, and no more, to be drawn for the job.

By this time it will be seen that the machine and the operator are in possession of the raw material and the tools. It is only necessary then to issue the Shop Prints and Job Cards for the work to be proceeded with. Process




Works Organisation.—Fig. 10.

issued to the central file in the shop foreman's office, fills in the reference particulars on both copies of the orders to which it has reference. The Process Clerk and Rate-fixer supervises test operations, and times and fixes piecework rates, enters on both copies of the Works Order the Machine No. on which work is to be carried out, and notes the approximate time or date when that work should be completed by the machine on which it is to be operated.

As soon as it is decided to issue the job to a departmental foreman, the date is noted on both copies of the Works Order, and one copy is sent to the Schedule Department, *via* the Progress Clerk, as a notification of the work having been put in hand. The Works Order, the Process Sheet, one set of Shop Prints, and the Stores Vouchers, together with the Tool Withdrawal Card received from the Tool Designer, are then issued as a complete set to the Sheets are placed in a permanent file in the Shop Foreman's Office for reference to by charge hands, etc., Fig. 6.

## Inspection.

Upon completion, the man passes the finished work to the next operation—if no intermediate viewing is necessary—the foreman always noting on the Works Order that the stated amount of work has been completed. In the case of piecework it will, of course, be viewed by the Inspection Department, and in this case the finished work goes through with the Works Order, the Inspector noting on the latter the number passed and the number scrapped.

With regard to the finished goods, upon these being presented by the Operator, the Inspection Department makes out the inspection slip in triplicate; one copy goes to the Wage and Cost Office, forming the Payment Voucher, the second copy goes to the Operator, forming Wage Payment

Slip, and the third copy goes to the Finished Stores with the goods, forming the Stores Inward Voucher. This voucher is passed on to the Stores Record Office by the Finished Stores and is collected and amalgamated with the other information passed to the Cost Office.

It will therefore be seen that no single document is issued without its having a final destination, but a great deal depends upon an energetic Progress Clerk, who would arrange his own clerical system in such a manner that enquiries would be instituted immediately any documents became overdue.

The Foreman then collects from the Operator the Works Order signed by the Inspection Department, the Job Card, the Shop Prints, and the Process Sheet. The Job Cards are then entered on time sheets and forwarded to the Cost Office. The completed Works Order and the Shop Prints are then passed back to the Progress Clerk in the Production Engineer's Office. The completed Works Order then releases from the Progress Clerk's "live" file the copy Works Order he has there. This is then filled in with the date of completion and number of pieces completed and forwarded to the Schedule Department as an intimation that that particular section of the Production Order is finished.

It should be noted here that, in order to keep track of the progress of work called for on each Production Order, it is necessary to have some form of bookkeeping which will show at a glance the exact position of every portion of the contract in order that certain sections can be speeded up.

For this purpose the authors designed what is known as a "Progress Ledger," and in this there is opened, what might be termed, a Ledger Account for each Production Order. The Shop is debited with every Works Order issued, and credited with every one returned completed.

As will be seen from the specimen, Fig. 7, this shows the number of parts called for by the Production Order. There is also shown the number of Works Orders issued covering that quantity, and on the right of that is shown the actual quantity completed to those Works Orders. Any deficiency to be made up owing to scrap must only be done on a Sub-Works Order, which should be a distinctly coloured card, and a separate set of Stores Withdrawal Vouchers must be issued with it. This Sub-Works Order would only be issued by direction of the Chief Engineer. By this means it will be seen that at any time the progress of any particular order, or part of an order, can be easily ascertained.

*(To be continued.)*

## SYNCHRONISING GEAR.

By F. Ashton.

*(Concluded from page 375.)*

### Illuminated Synchronism Indicators.

A synchronism indicator which has been used more extensively on the Continent of Europe than in this country, depends for its action upon the light given out by a number of incandescent lamps. In the centre of a circular case is a conical reflector on which is thrown a strong light with a sharp shadow. The front of the case bears the inscriptions "Too fast" and "Too slow," and the rotation of the light around the reflector shows in the same way as a revolving pointer, whether the speed of the incoming machine ought to be decreased or diminished. To understand how this instrument works, it is convenient to imagine that some lamps are joined across the switches of a low-voltage machine, such as a rotary converter, so that the circuit between this machine and those running on the bus-bars is completed through the lamps in the same way as when lamps are employed for synchronising in the ordinary manner. Each batch of lamps forms, under these conditions, a path across each of the switches in the same way as the switch blades form a path when the switches are closed. As the machine approaches synchronism the lamps will all light up and become dark simultaneously, but if the lamps are connected across unlike phases they will glow one after the other. Let the top contacts of the switches be designated A, B, C, and the bottom contacts in which the blades are mounted $A^1$, $B^1$, $C^1$. To make the lamps glow in succession, one batch must be connected directly across one of the switches, say, across contacts B and $B^1$ in the usual way, but the other two batches must not be connected across corresponding contacts. Contact A must be connected through the lamps to contact $C^1$ and contact C to contact $A^1$. The result of this is that when the machine is being brought into synchronism the lamps will glow in succession. When high-pressure alternators are being paralleled the lamps must be connected up through transformers, but this makes no difference to the general principle of the instrument we are considering. With lamps connected in the above manner and arranged in a circle around the inside of a circular case with a reflector at the back and a metal plate at the front with a hole in the centre so that the reflector only is exposed, the effect of the lamps lighting up in succession, as the incoming machine approaches synchronism, is to produce a revolving light in the centre of the case, and the direction in which it revolves is determined by whether the incoming machine is running too fast or too slow. The lamps that are connected across corresponding switch contacts (contacts B and $B^1$ in the case under consideration) will not be burning when the point of synchronism is reached, and if a voltmeter be connected in parallel with these lamps, as is generally the case, when the machine is in phase with those already running on the bus-bars, the needle will, of course, stand opposite the zero mark. There are usually six lamps in these instruments, and those that are diametrically opposite are connected in parallel. It will, of course, readily be seen that, in the great majority of cases, transformers will have to be used in conjunction with these instruments, but for pressures of 250 volts resistances in the form of additional lamps may be utilised. If it is desired that the voltmeter shall give a maximum reading at the moment of complete synchronism, then a transformer is required which produces a phase displacement of 180 deg. of one of the pressures under comparison.

### Instruments with Moving Pointers.

Instruments known as synchroscopes and in which a moving pointer indicates whether the incoming machine is running too fast or too slow are now most commonly employed for synchronising alternators. They are not all constructed on the same lines, but there is no difference in the general principle. In one case a bi-polar field system is built up of iron laminations, and upon the limbs fine wire coils are wound in exactly the same way as on the field magnets of a small dynamo or motor. These coils are either connected directly across two of the station bus-bars or to a bus-bar transformer. Between the poles of the field magnets an armature is placed which is free to revolve and upon the armature there are two windings approximately at right angles to one another. One end of one of the windings is con-

nected to the corresponding end of the other winding, and the junction so formed is connected to a slip ring mounted on the armature shaft. The two remaining ends of the windings are connected separately to two other slip rings, also mounted on the shaft. The armature windings are fed from the incoming machine, but only form one phase of it. One wire from the incoming machine feeds two of the slip rings, the current to one ring passing through a non-inductive resistance, and that to the other ring through a reactance coil. The third ring is fed directly from a different machine lead without any inductance or resistance in the circuit. One winding is thus made highly inductive, whilst the other is non-inductive. The current in one coil therefore lags behind the electromotive force by nearly 90 deg., whilst that in the other coil is practically in phase with it. On connecting the armature to the incoming machine, or to a transformer fed by it, a revolving field is set up around the armature, and the speed of this field measured in revolutions per second is exactly equal in cycles per second to the frequency of the incoming generator. As the field winding is excited directly from the bus-bars or from a transformer connected to them there will be set up in the air gap between the poles and the armature an alternating field having the bus-bar frequency which may be represented by the letter $f$. Calling the frequency of the incoming alternator $f^1$, then the field around the armature in the instrument will obviously revolve at that frequency. The interaction between these two fields, having frequencies $f$ and $f^1$, will cause the armature to rotate at such a speed and in such a direction that the rotary field synchronises exactly with the field set up by the stationary magnets. If $f^1$ be greater than $f$, then the armature will rotate at a speed of $(f^1 - f)$, and in a clockwise direction; but if, on the other hand, $f^1$ be less than $f$, then the armature will rotate in the opposite direction and with a speed of $(f - f^1)$. When $f = f^1$ the armature and pointer attached to it will take up a position of zero torque, thus indicating that the incoming machine is running in synchronism with those already on the bus-bars.

### Synchroscopes without Rubbing Contacts.

Another type of synchroscope with a moving pointer differs from the instrument just described in that it has no slip rings or brushes or other rubbing contacts, and although it is only really necessary when synchronising a poly-phase alternator to compare the frequencies and phase relations on one phase of the incoming machine and bus-bars, these instruments are made to operate with single, two and three-phase current. But as it is possible and quite satisfactory, once the machine connections have been properly made, to parallel a polyphase alternator by synchronising one phase only there is obviously no difficulty in the way of using a single-phase instrument, even if the alternator be wound for two or three phases. As a matter of fact, single-phase synchroscopes are usually adopted irrespective of the number of phases for which the alternators are constructed, and it will suffice in dealing with these instruments, without slip rings or rubbing contacts, to consider only the single-phase type. The principle is the same as that of the instruments with slip rings, but all the coils are stationary. Two rectangular coils are set at right angles in the same vertical plane, and one coil is connected in series with a non-inductive resistance, and the other with a highly-inductive resistance. These two coils, with their respective resistances and inductances, are connected in parallel and across two of the bus-bars. The revolving field which they produce therefore revolves at a speed corresponding to the bus-bar frequency. A small fixed coil having its axis in a horizontal is placed in the centre of these coils, and is connected through a non-inductive resistance to the incoming machine. Through the centre of the coils a pivoted spindle passes to one of which is attached a pointer, whilst at points between the internal and external coils the spindle carries two sector-shaped iron vanes fixed so that in any position they balance one another. These vanes constitute the moving armature of the instrument. When current is sent from the incoming machine into the smaller internal coil, it magnetises the armature, and it turns round and will take up a position in the rotating field, which corresponds to the direction of this field at the instant when the iron sectors are magnetised to their maximum strength by the internal coil, which is connected to the incoming machine. If the frequency of the current in the external coils which produce the revolving field be less than that of the current in the internal coil which magnetises the armature, then the latter must turn in order that it may be parallel with the field when its poles are at their maximum strength. Consequently, rotation of the armature, and therefore the pointer attaching to it, shows a difference of frequency between the bus-bars and the incoming machine and the rate of rotation, as in the other instruments, indicates the amount of this difference, whilst the direction of rotation shows whether the incoming machine is running too fast or too slow.

### Synchroscope Connections.

It is perhaps scarcely necessary to state that in connecting up synchronising gear great care must be exercised to ensure that the connections are properly made. It is a very simple matter indeed to make a synchroscope or voltmeter show a perfect state of synchronism when, as a matter of fact, the phase of the incoming machine is exactly opposite to what it ought to be. It is equally important when a new machine is about to be switched on to the bus-bars for the first time to ensure that when the switches are closed like phases will be connected together. In the event of unlike phases being coupled to one another or the synchroscope showing a false reading, as the result of incorrect connections, very heavy currents may circulate between the machines which are apt to cause considerable damage. The connecting up of synchronising gear and the testing of phases are best left to skilled electricians thoroughly accustomed to such work, although if the proper tests are applied carefully there is no reason why anyone with a fair electrical knowledge should not parallel new alternating-current generators with perfect success. How the proper tests should be made can easily be shown with a few simple diagrams, and with this matter the writer hopes to deal at some future time.

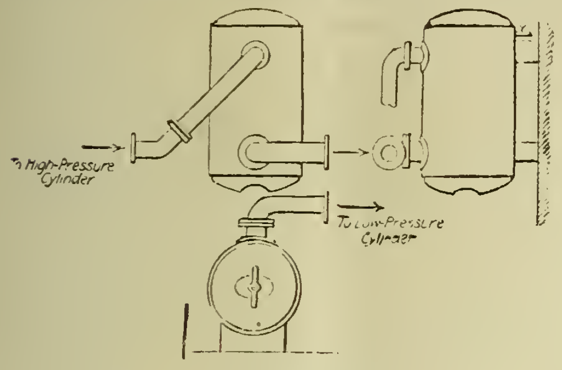
*(Concluded.)*

## RECEIVERS.

By H. Hamkens.

On compound steam engines trouble may be experienced with the receiver, which is often too small to give a good steam distribution and cut-off in the low-pressure cylinder, is treated as inferior and superfluous, and is made without regard to strength and efficiency. Accidents to receivers are

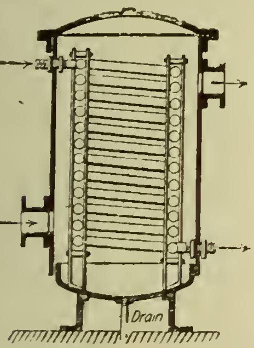
multiplying, and it is about time that they were watched more closely. They should be of ample size—that is, from $1\frac{1}{2}$ times to twice the piston displacement of the low-pressure cylinder. This ratio should be carried out on cross-com-




Receivers.—Fig. 1.

pound and tandem-compound engines alike. It is a mistaken idea that tandem-compound engines do not need a receiver.

The piping to and from the receiver, the receiver itself, and also the low-pressure cylinder should be made strong enough to carry the full boiler pressure—not as a working pressure, but for emergency. The old way of making



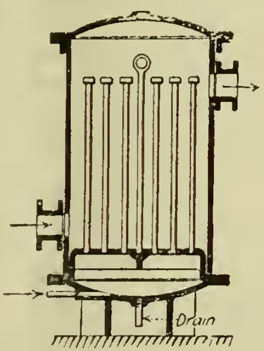
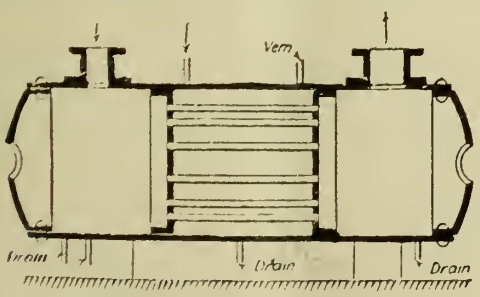




Fig. 2. Receivers. Fig. 3.

low-pressure cylinders of light weight and also light receivers and pipe connections is extremely dangerous, for if anything happens to the high-pressure steam valves or their gear to prevent closing of the valves, steam under full pressure will blow into the receiver through the high-pressure exhaust valves when they open. Every receiver should be provided with at least one safety valve—not a small relief valve to indicate when the receiver pressure has reached the danger point, but one that has an opening about three-fourths the area of the high-pressure exhaust; or, better, it might have two safety valves of the locomotive type, with large pipe connection to the outside of the building.



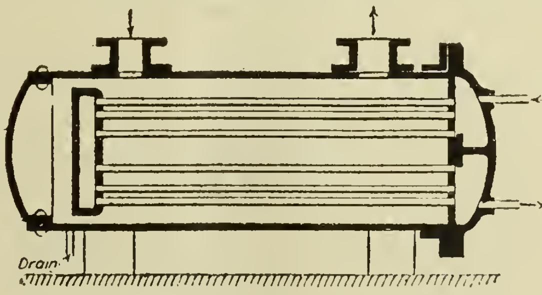
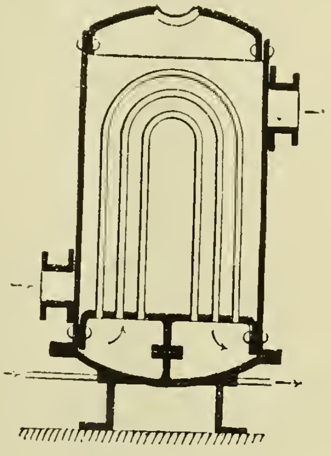




Fig. 5. Receivers. Fig. 6.

A vertical receiver with the high-pressure exhaust entering near the bottom and the low-pressure steam pipe leaving at the top is a good arrangement, but there may be occasions when a horizontal receiver would be more convenient. The advantages of the vertical receiver lie in the ease of draining and of reheating, if this be necessary; its disadvantage in the fact that it cannot be located very conveniently, unless there is a basement that affords sufficient headroom under the engine room. If the receiver extends above the floor line it takes up valuable space and is rather unsightly. There are no objections to the horizontal received, if well drained.

The arrangement shown in Fig. 1 can be recommended for cross-compound engines. The receiver is located in the



Receivers —Fig. 4.

basement sufficiently low for the exhaust pipe from the high-pressure cylinder to be connected to a flange on the top at one end, and for the low-pressure steam pipe to be connected to another nozzle at the other end. Any condensation carried over from the high-pressure cylinder and the water that accumulates from condensation in the receiver itself will collect if in the bottom, so there will be no danger if it should slope towards the end at which the high-pressure exhaust enters, where a large drain pipe should discharge the water into a trap. The receiver should be made of steel plates to conform with the specifications adopted by the American Boiler Manufacturers' Association, and the heads should be dished to a radius equal to the diameter of the shell. One of the heads must be provided with a standard manhole. The nozzles should be of heavy design and riveted to the shell, with caulking strips under the flanges. The seam of the shell should be made on the upper half, never at the bottom. The receiver may be supported on concrete piers, but not bolted down, with allowance for expansion and contraction.

Reheating receivers are sometimes called for and installed, but except on pumping engines the reheating part is usually

put out of service. If a reheater is desirable, the vertical receiver gives the best results. The reheater should consist of a copper coil, the steam to enter at the top; the lower end connected to a trap. The area of the reheating surface in square feet should be equal to about twice the volume of the low-pressure piston displacement in cubic feet. The exhaust from the high-pressure cylinder should enter at the bottom, the nozzle for connection to the low-pressure cylinder to be near the top. Fig. 2 shows a vertical receiver with copper coil, and top consisting of a flange riveted to the shell with a cover bolted on, so that the reheating coil can be inspected and removed if necessary. Both the flange and cover should be of cast steel, thoroughly annealed, of about 60,000 lbs. tensile strength. Cast iron must not be used for receiver heads, as it will give trouble. A drain in the bottom will take care of any condensation.

Reheating pipes or coils in receivers act about the same as radiators in rooms; in fact, they are radiators and subject to similar conditions. Unless properly vented, air contained in the steam will accumulate in certain places and materially reduce the heating capacity. For this reason the arrangement shown in Fig. 3 should be avoided. The vertical tubes, closed at the top with a cap and screwed into the plate at the bottom, will soon fill with air; in fact, there is no way of exhausting the air from them except by a vacuum pump. Having no vent, their heating effect will be destroyed.

If the tubes are arranged as shown in Fig. 4, the air can be forced out so that they will have the full heating effect, but the trouble with this design is that the tubes are liable to get loose in the plate on account of the constant vibration caused by the inrushing and outrushing steam; if once loose they will soon begin to leak. There is no saving in steam in a reheater with leaky tubes.

In a horizontal receiver a copper coil seems to be out of place; water will constantly collect in the lower parts, and there may be trouble on account of this; the drainage of the coil will be badly impaired. Therefore one of the two designs shown in Figs. 5 and 6 may be adopted. Fig. 5 shows two flanged steel heads riveted inside to the shell of the receiver, with steel tubes expanded in place. Brass tubes must not be used, as they will give trouble on account of unequal expansion. Both ends should have a manhole, so that the inside of the receiver and the ends of the tubes can be inspected. Fig. 6 shows another design with horizontal tubes which may freely expand and contract.—*Power.*

## ECONOMIES IN THE GENERATION AND USE OF STEAM.

### ADVANTAGES IN THE USE OF HIGH-PRESSURE STEAM.

By Sydney F. Walker.

(*Continued from page 366.*)

### The Care of a Boiler under Steam.

Take the case of a boiler when first put under steam, omitting, of course, the heat absorbed in raising the temperature of the boiler itself and its accessories, and consider what happens to the steam after it begins to be formed at the standard pressure 212 deg. Fah., or 100 deg. Cen. If the steam is now allowed to flow out of the boiler, more and more steam is formed, and the increased quantity of steam present in the steam space of the boiler commences to exert a pressure upon the boiler, and upon the steam itself; this pressure tends to liberate heat just in the same way as when air is compressed, and the increased temperature due to the heat liberated by the increased pressure causes the steam to endeavour to expand. It will be remembered that all gases and vapours expand, if they are free to do so, $^1/_{461}$th part of their volume for each increase of temperature of 1 deg. Fah., or $^1/_{273}$ of their volume for each increase of temperature of 1 deg. Cen. Where the gas or vapour is confined, as in the steam boiler, the steam tries to expand, and, not being able to, increases the pressure; the net result being a continued increase of pressure as more and more heat is delivered to the steam, and a corresponding increase of temperature. If the steam tables be further examined, it will be found that as the pressure and temperature rises, the latent heat falls. In the old tables, the latent heat of steam at atmospheric pressure, and 212 deg. Fah. is given at 965·2 B.Th.U. per pound; in the new tables the figure is 971·7; at 45 lbs. per square inch absolute pressure a little over 30 lbs. gauge pressure; the old pressure employed to such a large extent in boilers 40 years ago; the latent heat has fallen to 920·9 B.Th.U. per pound, according to the old tables, and 930·5 according to the new tables. At 95 lbs. per square inch absolute, a fraction over 80 lbs. gauge, a pressure that was used for a long time, and that may still be found in some of the older boilers at the present day, the latent heat has fallen to 885·8 B.Th.U. per pound according to the old tables, and 893·4 according to the new tables. And so the figures go on, the latent heat at 265 lbs. per square inch absolute, approximately 250 lbs. gauge, being 826·8 according to the old tables and 820·7 according to the new tables. It is perhaps interesting to note, *en passant*, that while for the lower pressures the latent heats in the old tables were lower than those in the new tables, the latent heats for the higher pressures are lower in the new tables. In the old tables, pressures above 250 lbs. gauge are not often found; in some pocket-books they are given up to 300 lbs. absolute; but in the new tables they are carried up to pressures of 1,200 lbs. per square inch absolute, so that we can compare the increased range of temperature that will be available if steam engineers are able to carry out their wish of increasing the working pressures up to 500 lbs. per square inch gauge. At 500 lbs. per square inch gauge, approximately 515 lbs. absolute, the temperature of the steam would be approximately 450 deg. Fah. It will be remembered that the efficiency of a heat engine is determined by the formula

$$E = \frac{T_1 - T_2}{T_1},$$

where $T_1$ is the absolute initial temperature, the temperature in this case to which the steam is raised in the boiler, and $T_2$ is the final temperature at which the steam is rejected finally, and E is the efficiency. In the case of steam plant, the final temperature, when working without a condenser, is that of a pressure a few pounds above the atmosphere; and working with a condenser is the temperature due to the vacuum obtained in the condenser. Taking the case first, which was quite common 40 years ago, of a steam plant working at 30 lbs. per square inch gauge pressure, and exhausting to the atmosphere, and taking the exhaust pressure to be, say, 20 lbs. per square inch absolute, the figures in the above formula will be

$$E = \frac{274 - 228}{274} = \text{approximately } 0·164; \quad 16·4 \text{ per cent.}$$

Taking again the figures for an ordinary modern steam plant, with a boiler pressure of 120 lbs. gauge and a condenser pressure of 0·5 lbs. per square inch, the figures are

$$E = \frac{350 - 79}{350} = 0·774; \quad 77·4 \text{ per cent.}$$

This is a very low condenser pressure; it is taken merely to illustrate the

effect of high vacua in the condenser, even with ordinary steam pressures, according to present boiler practice. Taking the figures of the highest boiler pressures used in modern plant, 250 lbs. per square inch gauge, and again a condenser pressure of 0·5 lb. per square inch, the figures are $E = \frac{406 - 79}{406} = 0{\cdot}80$; 80 per cent. Taking 120 lbs. gauge boiler pressure, and a condenser pressure that is far more common, 2½ lbs. per square inch, or, as it is usually written, 25 in. of vacuum, the figures are $E = \frac{350 - 134}{350} = 0{\cdot}60$; 60 per cent; and with 250 lbs. gauge boiler pressure, and 25 in. vacuum, the figures are $E = \frac{406 - 134}{406} = 0{\cdot}67$; 67 per cent.

Carrying the matter farther, and taking the highest boiler pressure that has been suggested, 500 lbs. per square inch gauge, and a vacuum of, say, 28 in., a figure that is constantly obtained with modern condensing plant, the formula works out as follows, $E = \frac{470 - 101}{470} = 0{\cdot}785$; 78·5 per cent.

The temperatures in the above calculations have all been taken from the new tables.

The above figures, the writer believes, will be found exceedingly instructive; the important influence of the condenser, for instance, upon the range of temperature, is very striking; and the very slowly increasing advantage obtained, as the boiler pressures are raised. This last accounts, to a large extent, for the comparatively low boiler pressure of 120 lbs. being so much employed, and for the whole question of higher pressures having been put on one side when practical steam turbines that were able to use very high vacua came on the market. The advantage to be gained from increased pressure at the top of the scale was small compared with that obtained by higher vacua at the bottom of the scale. Now that the lower end of the scale has apparently reached the practical limit, steam engineers are turning their attention again to higher boiler pressures.

In the next article, the writer proposes to deal with the difficulties in the way of using high steam pressures, so as to obtain the nearest possible approach to theoretical efficiency.

*(To be continued).*

## FUEL OIL FOR STATIONARY POWER PLANTS.

By FREDERICK EWING.

*(Concluded from page 365.)*

### The Air Supply.

One of the most important questions in the combustion of fuel oil is the regulation of the air supply. In a properly-designed furnace the grate bars are removed and a firebrick floor with carefully planned air openings is laid on pieces of 2-in. pipe extending across the firebox. The air supply is admitted through these openings in the furnace floor so that it will come in close contact with the atomised oil and complete combustion will take place before the gases come in contact with the heating surface of the boiler.

The required amount of air should be regulated by opening or closing the stack damper and not by opening or closing the ashpit doors, which should be left open at all times. Regulating the air supply is generally done by hand, but a more satisfactory and economical way is by the use of an automatic damper regulator operated by the gas pressure in the furnace. The most efficient draught at which an oil-fired boiler should be operated is from 0·01 in. to 0·06 in., depending on the capacity at which the boiler is operated. A slight variation in the air supply will affect furnace conditions in an oil-burning boiler more than the same variations where coal is used, therefore particular attention should be paid to this point. Fuel-oil installations should be as far as possible in duplicate.

### Regulating Speed of Pumps.

The speed of the pumps should be regulated by a diaphragm valve connected to the main steam line. This will increase or lessen the quantity of oil feed to the burners, as may be demanded. The exhaust steam from the oil pump should be utilised to heat the oil before it reaches the burners. Strainers in duplicate should be installed on the discharge side of each pump. A circulating pipe system is essential, so that when starting the plant after it has been shut down and the oil allowed to become cold in the pipes, the burners can be by-passed and the oil circulated through the system and heated so that hot oil is supplied to the burners. Provision should be made for removing any condensation from the steam lines leading to the burners, and these lines should be thoroughly insulated.

In plants that shut down on Saturday until Monday morning, it is necessary to instal a small auxiliary boiler, which can be fired with wood or coal so that steam can be provided for atomising and operating the pumps when the plant is to be started.

It is impossible to give an exact comparison of efficiency between coal and oil for all plants, as no two are operated under similar conditions. Under favourable conditions 1 lb. of oil will evaporate from 14 lbs. to 16 lbs. of water from and at 212 deg.; 1 lb. of coal will evaporate from 7lbs. to 10 lbs. from and at 212 deg.; 1 lb. of natural gas will evaporate from 18 lbs. to 20 lbs. from and at 212 deg.

In the last three years several comparative boiler tests under regular service have been conducted at plants in New England to make a comparison between coal and fuel oil; the tests covered a period of one week each, starting with cold boilers Monday morning and continuing until Saturday, when the plants were shut down. Hammel oil-burning equipment was used throughout in each plant.

COMPARATIVE RESULTS COAL AND OIL FUELS.

| | Manville Mill. | Jenckes Spinning Co. | Bernon Mill. | Riverside Mill. |
|---|---|---|---|---|
| Evaporation per pound of coal from and at 212 deg. Fah. | 10·31 | 10·02 | 10·24 | 9·71 |
| Evaporation per pound of oil from and at 212 deg. Fah. | 15·55 | 15·21 | 15·38 | 15·56 |
| Combined efficiency with coal, per cent | 68·0 | 66·6 | 68·1 | 67·2 |
| Combined efficiency with oil, per cent | 80·8 | 81·5 | 80·6 | 81·5 |

In "Power" for March 13th, R. L. Wales gives a quick method of determining the relative cost of coal and fuel oil, based on comparative efficiencies, and labour saving, in which he shows that 36 per cent more per

B.Th.U. can be paid for oil than for coal. Although a fair idea may be obtained of the comparative cost of coal and fuel oil by making certain reasonable assumptions, the only way to determine the exact saving is to operate the plant with each fuel for a period long enough to get the necessary data on which to make a final decision.

*(Concluded.)*

## GAS-ENGINE TESTING.

By P. S. Rose.

All brakes work on exactly the same principle in that they absorb the power of the engine by frictional contact. The force necessary to overcome the friction is weighed, and this, with the length of the brake arm and the number of revolutions of the pulley per minute, enables the investigator to determine the horse-power, the formula for which is—

$$\text{Horse-power} = 602{,}432 \ W \ R \ N \div 33{,}000.$$

In this formula

W = net weight on scales.
R = length of brake arm in feet.
N = revolutions per minute of engine.

If the brake arm be made of such a length that 602,432 R = 33, it is evident that the above formula may be simplified to read—

$$\text{Horse-power} = P \ R \ \div \ 1{,}000.$$

The value of R in such case will need to be 5 ft. 3 in.

### Types of Brakes.

Fig. 1 illustrates one of the simplest types of brakes, consisting of a heavy wooden arm fitted with a belt to which a number of wooden blocks are fastened. This band is securely fastened to the arm at one end, having at the other a long adjusting screw and nut to obtain the correct pressure on the pulley. In using this brake, or, in fact, any brake, the tension must be so adjusted that the engine will pull its full load without any diminution in speed, and unless the brake is provided with some sort of cooling arrangement to avoid causing it to grip the pulley, constant adjustment will be necessary. For cooling purposes, oil or soap may be used on small brakes and water on large ones.

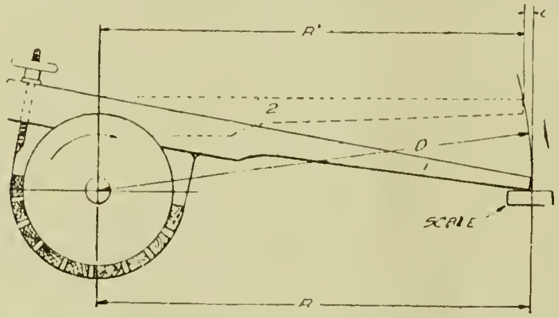



Fig. 1.

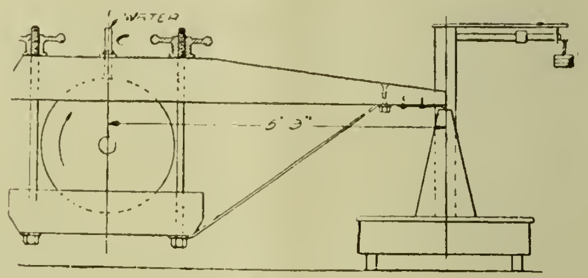



Fig. 2.

Gas engine Testing.

The brake just described should not be used on engines of more than 5 H.P. or 6 H.P.

An excellent type of water-cooled brake for use on engines up to 30 H.P. is shown in Figs. 2 and 3. Fig. 2 shows the assembled brake, and Fig. 3 the pulley side of one of the brake shoes. Each shoe covers about one third of the pulley circumference, and has grooves formed in the concave surface so as to distribute the water, which is admitted at a pressure of about 30 lbs. at point *c*.

One of the best brakes is that known as the Alden, shown in Fig. 4, which is applicable to almost any size of engine.

This brake consists of a central disc of cast iron keyed to the crankshaft of the engine, and flanked on either side by a copper disc set into the brake housing by means of an expansion ring. Water is admitted under pressure between the housing and the discs, causing them to press tightly against the central revolving member, thus creating the necessary friction. The housing is provided with an arm which lifts a weight, and enables readings to be taken in the ordinary manner.

Obtaining the correct length of arm seems to be the most general source of error in making a brake test. The correct length of arm is the distance between two vertical lines, one passing through the centre of the engine pulley and the other passing through the point where the brake arm rests on the scales, as shown in Fig. 1, or lifts the weight.

If the arm is in the position 1, R is the correct length; but if the brake be turned in position 2, R[1] is the proper length to use. The use of the distance D from the centre of the wheel for the length of the arm in position 2 is in error by the amount *e* shown in the figure.

If a brake test be made of any ordinary gas engine, it will be found during the first period of the test, say, the first hour, that considerably more power will be developed than during the second hour. In other words, an engine that is able to develop 6 H.P. to 7 H.P. during the first

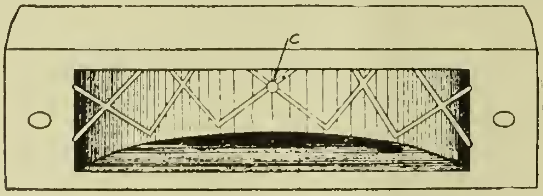



Fig. 3.

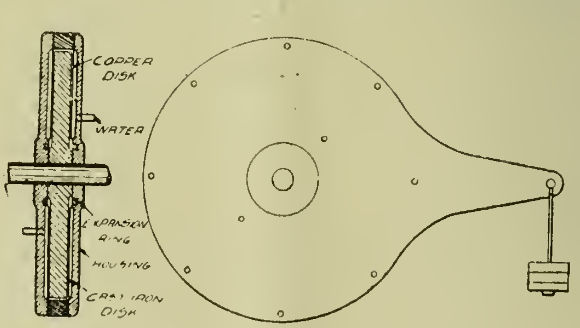
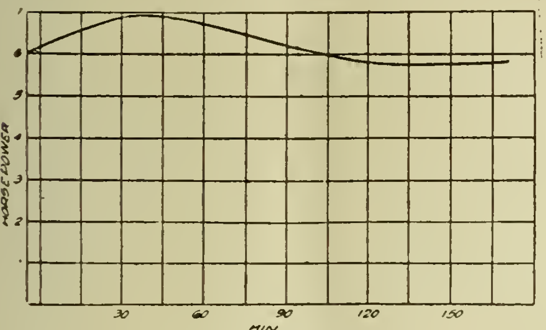



Fig. 4.

Gas-engine Testing.

hour of a two-or three-hour test will probably develop not more than 5½ H.P. during the last half-hour.

Fig. 5 is a curve showing the drop in power of an ordinary gasoline engine after having run an hour or two. It is shown that the power developed gradually increased

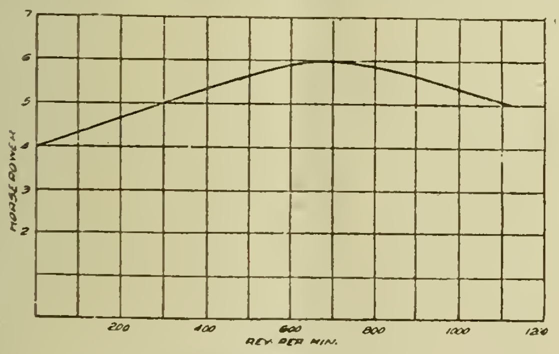



Gas-engine Testing.—Fig. 5.

the first 30 or 45 mins., after which it decreased until, at the end of two hours, it remained practically constant.

The reason for this peculiarity in gas-engine performance is probably due partly to increased friction due to the heat of the engine, partly to a burning of the lubricating oil and partly to a dropping off of volumetric efficiency as the cylinder gets hot. The latter is undoubtedly the largest factor in causing a decrease in power.

Fig. 6 is a curve showing the effect an increase of speed has on the power developed. Here it will be observed that up to a certain speed, a little beyond that for which the engine was designed, the power increases, but after a




Gas-engine Testing.—Fig. 6.

certain speed is reached the power curve drops rapidly. The reason for this generally lies in the size of the ports and the timing of the valves. The ports are designed to admit a certain volume of mixture in a certain time, and if, due to increase of speed, this time is much reduced, a full charge cannot enter, and as a result the power will decrease.—*The Gas Review.*

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The Electric Vehicle Committee.—At a meeting of the Electric Vehicle Committee, held in May, Mr. R. A. Chattock presiding, the officers of the Committee were re-elected for the current year, and the annual report and accounts submitted and approved. The question of marking upon the batteries of electric vehicles the working limits for specific gravity was again under consideration, and, in view of a report received from the accumulator makers' section of the B.E.A.M.A., wherein objections were set forth to the proposal, it was decided to drop the matter for the present. Several firms had written stating that they were giving serious consideration to the question of undertaking the manufacture of electric vehicles and equipments after the war.

# NOTES ON POLY-PHASE INDUCTION MOTORS.

By F. Ashton.

(*Concluded from page 377.*)

## The Protection of Induction Motors.

Induction motors, like continuous-current motors, must, of course, be protected against overloads with circuit breakers or fuses. In the case of squirrel-cage motors taking a starting current of perhaps three or four times greater than the normal full load, current protection against overloads presents a certain amount of difficulty, for it is obvious that if the circuit breaker or fuse will allow the heavy starting current to pass into the motor, it will not protect the machine against overloads. It is evident, therefore, that if fuses are employed which will blow at, say, 50 per cent above the normal full-load working current, they must be short during the starting period. Circuit breakers used for starting induction motors drawing large starting currents are sometimes fitted with a double rating device; that is to say, an additional weight is placed upon the solenoid during the starting period, so that the breaker does not open the circuit whilst the large starting current is flowing. In another instance, an auxiliary coil, which is only in circuit during the starting period, prevents the overload solenoids from operating whilst the motor is starting, but as the auxiliary coil is cut out of circuit as soon as full speed is reached, the breaker is, of course, free to operate at times of overload. It is the small induction motors that are connected directly across the mains without any pressure reduction that demand a current that is relatively large in comparison with the normal fullload current. With an auto-transformer or an ohmic resistance, the starting current can be greatly reduced. The current which a squirrel-cage motor draws at starting lags considerably behind the electromotive force, and it is owing to this, rather than to the magnitude of the current, that the pressure regulation of the circuit is impaired. Overloads lasting only a few seconds will not injure a motor, and provided they do not occur too frequently, the machine need not be disconnected from the circuit. With ordinary fuses and circuit breakers, however, instantaneous overloads will cause the circuit to be interrupted. To prevent this, use should be made of circuit breakers with a time lag: that is to say, the breakers should not operate until the overload current has been flowing for a definite period. Suppose a motor is rated at 10 H.P. and works at this output during the greater part of the time, but occasionally the demand upon it is 15 H.P. for a few seconds, this overload, of such small duration, will not cause the motor windings to overheat, but an ordinary circuit breaker or fuses arranged to open the circuit when the current is 50 per cent above the normal value will interrupt the supply each time the overload occurs. But with a circuit breaker having a time lag which will allow the overload only for such a period that will not cause injurious overheating, the difficulty is overcome. Many kinds of circuit breakers having time lag devices have been placed upon the market. Some depend for their action upon dashpots, others upon the expansion of metal strips which carry the main current. With all the time-lag circuit breakers that have been invented it is unnecessary to deal. All that need be said is that it is desirable that such circuit breakers should be capable of adjustment so that the time element can be set to suit

the prevailing conditions. Ordinary circuit breakers used for protecting induction motors are sometimes made to operate with a time lag by shunting the trip coil with a fuse. Normally, the current flows through the fuse and not the trip coil, but when the fuse blows as the result of the overload being maintained, the current passes into the trip coil and the circit breaker opens. It is necessary, with three-phase motors, to provide a circuit breaker in two of the three line wires, for if only one line wire is protected, an overload will, of course, cause the motor to run as a single-phase machine, and the current in the windings that are operative will be very much greater than that which passed into the motor when all the phases are in use. Even if the motor is only partially loaded an interruption of the current in one phase will result in a considerable increase in the current in the other phases. To obviate the necessity for using circuit breakers in two of the line wires, however, it is sometimes customary to employ a single overload circuit breaker in the rotor circuit. This arrangement not only operates when the load on the motor exceeds a safe limit, but also protects the windings in the event of one of the stator phases being put out of action. It is obvious, however, that this scheme is only applicable to slip-ring motors.

## Speed Regulation.

With respect to speed regulation, induction motors are inferior to continuous-current motors. It is for this reason that in some large engineering works and other industrial establishments where fine speed regulation is required, the poly-phase alternating current obtained from the supply mains is sometimes converted into continuous current. With a continuous-current shunt-wound motor, designed for variable speed, it is possible to obtain a good range of speed by altering the amount of current flowing in the shunt circuit. With induction motor, on the other hand, the conditions are altogether different. There are only two methods of varying the speed of a squirrel-cage motor, neither of which are very satisfactory. One is to vary the pressure applied to the stator terminals and the other to alter the number of stator poles. As regards the first method, since the torque of an induction motor is proportional to the square of the applied pressure, it can easily be seen that in the great majority of instances the method is impracticable. The pole-changing method involves the provision of special pole-changing windings and a special switch for alternating the connections. The size and cost of a motor of given output are therefore increased. Moreover, pole changing does not give fine speed regulation, and two or three speeds are, as a rule, all that can be obtained by this method. The speed of an induction motor is dependent upon the number of poles and the periodicity, and when altering the speed by changing the number of poles, definite speed relationships must, of necessity, be adhered to. If the number of poles be doubled, then the speed drops to one-half. Intermediate speeds between the ratio of 1 to 2, for example, are not obtainable with squirrel-cage motors With slip-ring motors, it is possible to vary the speed by inserting resistance in the rotor circuit, but this method is a very wasteful one. At half speed, for instance, half the total amount of energy supplied to the machine is dissipated in the rotor resistance, and it is clear that when motors have to run at low speeds for long periods this method is very expensive. What is sometimes done in the case of slip-ring motors is to combine the pole-changing method with the rotor resistance method; that is to say, the wide speed ranges are obtained by pole changing and the intermediate speeds by inserting resistance into the rotor circuit. This method is obviously much more efficient than obtaining the whole of the speed variation with the rotor resistance, for pole changing does not involve waste. Another method of obtaining speed regulation with induction motors, which, however, is seldom used, is to connect two machines in cascade. One motor has its stator connected to the source of supply, and the rotor of this motor is connected to the stator of the other motor. Both motors are connected to the same load usually by gears. With the same number of poles on each machine, the motors will run at half their normal speed, but on connecting the primaries of the motors to the supply in the ordinary way, they both run at their normal speed; that is, a speed slightly below the synchronons value.

## Modified Induction Motors.

From time to time many modifications of ordinary squirrel-cage and slip-ring induction motors have been introduced, but with one or two exceptions they have made little headway. Slip-ring motors have been designed that run up to speed automatically on closing the stator switch, just like squirrel-cage motors. The rotor resistances are in the form of flat discs and are mounted on the motor shaft, and when the rotor begins to revolve a device actuated by centrifugal force comes into operation and moves a set of contacts across the resistance discs, thus cutting resistance out of the rotor circuit. When the stator current is cut off and the motor slows down the contacts move back again to their original position, and the resistance is again introduced into the circuit, ready for the next start. Motors stared in this way are not likely to come to grief when left to the care of careless and inexperienced people, for the starting arrangement is fool-proof. The starting torque of these motors is high, whilst the starting current does not exceed that of an ordinary slip ring motor. Another machine possessing these characteristics has several rotor windings having different resistances and inductances. At the moment of switching on the current to the stator the low inductance windings carry the bulk of the current, because at this instant the periodicity of the rotor currents is equal to that of the supply. Thus the reactance voltage of the windings having high inductance will be great and they will carry little current. When the motor gains speed, however, the rotor periodicity falls and the current in the rotor is transferred from the windings of high resistance and low inductance to those of higher inductance and lower resistance. At full speed the rotor periodicity is very low and the rotor current is carried almost entirely by the low resistance winding. It follows that as the rotor currents are confined to high resistance winding when the stator switch is closed, the starting torque is good and the starting current not excessive. There are other special forms of induction motors, but the bulk of the machines now in operation are built on orthodox lines. The drawback to most of the modified induction motors is that they are more complicated and more expensive than motors built on normal lines. Some of the American and Continental firms build poly-phase motors with commutators with a view to obtaining speed regulation. It is evident, however, that although such machines may possess distinct advantages for certain classes of work, as, for example, for driving machine tools, they do not show any advan-

tage over continuous-current motors as regards robust construction and simplicity. Perhaps the most successful form of modified induction motor built in this country is the Cascade motor, built by the Sandycroft Co. For mining work, these motors are very suitable, because there are no rubbing contacts, and it is possible to run these machines at very slow speeds.

**Power Factor.**

The principal disadvantage of induction motors, from the power-station engineer's point of view, is that they have a bad effect upon the power factor. Although any class of inductive apparatus tends to create this undesirable state of affairs the induction motor is by far the most troublesome of this respect, for owing to magnetic leakage these machines take a wattless component of from 25 to 30 per cent of their kilovolt-ampere rating. On many large power systems where many induction motors are connected to the mains, the capacity of the generators and mains has been greatly reduced as the result of these lagging magnetising currents. This has led electrical engineers to devise methods of eliminating those currents. Large induction motors are now sometimes fitted with phase advancers, which put exciting current into the rotors and so prevent the machines from drawing the magnetising current from the mains. Another method of grappling with the difficulty is to insal synchronous motors on different parts of the system, and when these motors are over excited the lagging currents are compensated. Electrostatic condensers have exactly the same effect. A condenser or over-excited synchronous motor may be regarded as a reservoir for receiving the wattless currents set up by induction motors on other parts of the circuit, and either of these arrangements may be employed with advantage for raising the power factor.

*(Concluded.)*

## DIESEL ENGINE USERS' ASSOCIATION.

The May meeting of the Diesel Engine Users' Association was held at the head offices of the Chelsea Electricity Supply Co. Ltd. The building of the Institution of Electrical Engineers, at which the meetings have heretofore been held by kind permission of the Council, has been taken over for war purposes by a Government Department. It was announced that the following meeting would be held during the week in which the Incorporated Municipal Electrical Association would be holding its annual meeting, as it was thought that this would be a convenience to several of the members who might be coming up to London from the provinces at that time. A very instructive and interesting paper on the subject of "Tar Oil Fuel and Diesel Engines" was read by Mr. Geoffrey Porter, A.M.Inst.C.E., president of the association, in which he dealt at length with the question of tar oil specifications and the quality of the oils offered by distillers, and further with facts observed and inferences to be drawn from actual experience. In view of the present high prices ruling for imported residual petroleum oils, which have until lately almost exclusively been used in this country as fuel for Diesel engines, and of the increasing difficulty of obtaining sufficient supplies of this class of oils in present circumstances, the problem of the successful use of tar oils produced at home is not only of the greatest interest to users of Diesel engines, but is of national importance as well. Mr. Porter's statement of the experience gained up to the present in connection with this class of fuel will be of great assistance to many users and prospective users, and the discussion on the subject, which is to take place at the next meeting, should be of very considerable interest.

# Review.

*Commercial Photography.* By Practicus of the "B.J." London: Henry Greenwood and Co. Ltd., 24, Wellington Street, W.C. 2. 1s. net.

Industry owes a very considerable debt to photography, particularly in relation to the illustration of new machines, buildings, and works of various kinds in technical journals or catalogues. Readers of the former must have noticed the very considerable improvement that has taken place in half-tone illustrations of recent years. Although the block maker has had something to say in regard to this, he could not have produced such good results if the original photograph was poor. We have seen—and have it in our office at the moment—a photograph of a machine that never existed. It was drawn up by a skilled artist, the drawing photographed, and a very realistic block made. This was a fake, but such are few and far between, and the block maker has usually to depend on the photographer to supply him with a good photograph. It is not only essential that the negative shall be sharp and clear. There are a vast number of important matters to take into account, especially when reproductions of machinery are required. The little work under review is excellent in its practicality—to coin a word. It gives a great number of details as to the best methods to adopt in photographing a variety of objects. The treatment—by painting of machinery—the arrangement of a suitable background—the picking out of print indicating the name of the makers—all these and more will be found in the book. Latterly it has been usual in certain cases to pick out certain parts of a machine and to merely indicate the others. This "ghost" or "phantom" work is chiefly done by the block maker or toucher-up, but the advantage of a good original is clearly indicated.

Expenditure of Ammunition.—That the expenditure of field artillery ammunition in the present war has been enormous, and beyond any conception based upon previous experience, is well known, but, like many other matters of importance, exact data have not generally been available. The following, taken from General Sixt von Arnim's report concerning the battle of the Somme, July, 1916, are extremely interesting, in that they give the maximum expended in any one day of 24 hours, and the average daily expenditure during the entire month of July, 1916: (1) Maximum artillery ammunition expended in any one day of 24 hours: 77-mm. field gun, 322 rounds per gun; 105-mm. field howitzer, 479 rounds per gun; 150-mm. howitzer, 233 rounds per gun; 105-mm. gun, 321 rounds per gun; 210-mm. mortar, 116 rounds per gun. (2) Daily average (24 hours) during July, 1916: 77-mm. field gun, 145 rounds per gun; 105-mm. field howitzer, 170 rounds per gun; 150-mm. howitzer, 119 rounds per gun; 105-mm. gun, 118 rounds per gun; 210-mm. mortar, 51 rounds per gun. (3) One field battery (howitzers) expended in one day 3,500 gas shells. The actual number of guns in action is not known. The best information gives a probable number of one field gun, exclusive of heavy types, for every 20 yards of front The approximate frontage of the Somme battle was 40 miles, so that the number of field guns engaged numbered in the vicinity of 3,500. Each gun fired 145 projectiles per day, or a total of 4,495 for the month, and the total fired becomes 15,732,500. The German 77-mm. projectile weighs seven kilogrammes, or 15·4 lbs., so that the total weight fired was 242,280,500 lbs., or 121,140·25 tons. The computed weight of the heavy artillery ammunition would probably more than double this amount. Such figures only serve to demonstrate the vastness of the conflict in Europe, and to point out to us the enormous difficulties of ammunition supply, both in manufacture and carriage to the guns. And we must remember that in the battle of the Somme the Germans were on the defensive and lost ground, so that the above expenditure does not even represent a successful defence. The figures also point out the difficulties in the way of a rapid advance after a line of fortifications has been pierced. First, the guns must be moved forward, in itself a slow and difficult task, over the broken and shell-torn ground; then, over the same ground, roads must be constructed, or the light field railway must be laid and a new ammunition supply established. The time necessary for these operations is much longer than that necessary for the defence to establish a new trench line, and the attacking infantry in modern war dare not go beyond the support of its artillery.—*The Field Artillery Journal.*

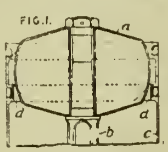
# Patent Applications.

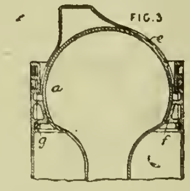
*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### CONNECTING-RODS.

105,085.—H. D. HENRY, 22, Grosvenor Road, Chiswick, London, H. D. HINDLEY, The Mount, Bourton, Dorsetshire, and T. J. BIGGS, 102, Middleton Hall Road, King's Norton, Birmingham.—Sept. 16th, 1916.—In an aeroplane or other engine, the connecting-rod is formed with a hollow head of nearly the same diameter as the cylinder, making a spherical joint with a sleeve sliding in the

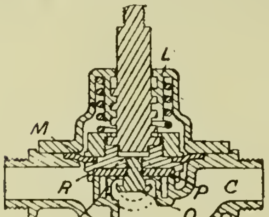




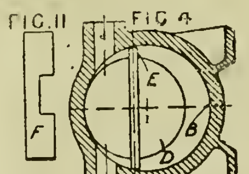
cylinder. In the arrangement shown in Fig. 1, the head *a* forms a spherical joint with a sleeve *c* provided with packing-rings. The head is inserted through slots *d* in the lower bearing-surface, and is then turned at right-angles and secured to the rod *b*. In Fig. 3, the head is shown secured between a cap *e* carrying a baffle and a lower bearing-ring *f* secured by a ring *g*. Alternatively, the sleeve *c* may be in two parts clasping the head *a* and secured together by a split ring of U-section. The sleeve may be formed with a spherical cap such as *e* clasped by a spherical plate bolted to the head *a*, the cap being slotted to permit oscillation of the plate.

### VALVES.

104,567.—H. L. DOULTON, Lambeth Sanitary Engineering Works, Lambeth, R. J. PLEACE, 31, Voltaire Road, Clapham, both in London, and L. B. WILLIAMS, 50 St. Leonard's Road, East Sheen, Surrey.—March 24th, 1916.—A screw-actuated lift valve is so arranged that the cold water supply alone acts on the underside of the valve member, the hot water acting against a flexible packing-diaphragm. During the first part of the opening movement, the valve member P lifts from its seat and allows cold water to flow from the passage C to the outlet passage F. A further movement lifts the flange R from the seat and allows a mixture of hot and cold water to flow; the final movement brings the disc O against the underside of the seat to shut off the cold water, while allowing the hot to flow. The packing diaphragm M is clamped between the casing and cover L and between two parts of the valve member.



Patent 104,567.



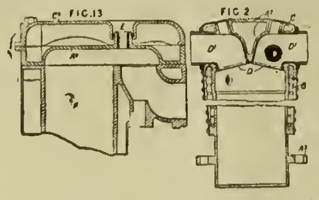
Patent 104,920.

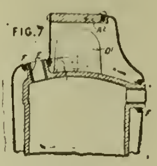
### ROTARY PUMPS, ETC.

104,920.—LACY-HULBERT & CO. and A. G. LONDON, Boreas Works, Beddington, Surrey.—March 23rd, 1916.—The radially-sliding vane E is made equal in length to the shortest chord of the cylindrical casing B drawn through the centre of the rotor D. At the point of contact with the rotor, the casing B is curved to fit the periphery of the rotor for a chordal distance at least equal to the width of the slot in the rotor. Two or more crossed vanes may be used of the cut-away form F shown in Fig. 11. Specification 1031/99 is referred to.

### INTERNAL-COMBUSTION ENGINES.

105,087. D. NAPIER & SON and A. J. ROWLEDGE, 211, Acton Vale, London. March 24th, 1916. Cylinders of aluminium or its alloys are cast in dies, either in one with, or separate from their heads. Steel liners to valve boxes D1, Fig. 2, are incorporated in the casting and may be split longitudinally, except at the seating D. Longitudinal T-shaped flanges B have the sheet aluminium jacket C attached to them by welding or screwing. A platform A2 for carrying the valve-gear joins the valve-spindle guides. The sparking-plug socket E is also embedded in the casting, and in order that the casting may be withdrawn from the mould when the socket is in the position shown in Fig. 7, a recess A6 is formed in the mould behind it and becomes filled with metal to be afterwards removed, or the mould or die carries a plunger which fills this recess and is withdrawn in the direction of the

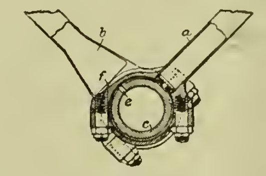




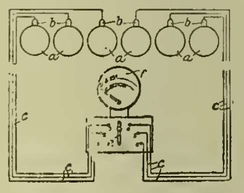
cylinder axis. The joint between the socket and the sheet-metal jacket is made with a ring of dermatine F. A number of cylinders may be cast together, either separately from, or integral with, their heads, which are also in one piece. There is a longitudinal pin such as B, Fig. 2, between each two barrels. In an alternative form, Fig. 13, the cylinder barrel and valve-chest are cast together with a separate cover made in two pieces A9, C3, having a water space between them. A cylinder head cast in dies may be used with a barrel cast in sand, or with a cast-iron barrel. The mould for the cylinders shown in Figs. 2 and 7 comprises two dies only, the joint being on the axes of the passages D1.

### CONNECTING-RODS; LUBRICATING.

105,091.—M. J. B. BARBAROU, 24, Rue St. James, Neuilly-sur-Seine, France.—March 25th, 1916.—In engines with converging cylinders arranged at 90 deg., two connecting-rods *a*, *b* are mounted on a common crank-pin *c*. The rod *a* is connected directly to the pin. The rod *b* is forked and mounted on surfaces formed on the big end of the rod *a*. The rod *a* receives its lubricating-oil through a hole *e*. A groove *f* is provided for the passage of the oil to the ends of the rod *b*.



Patent 105,091.



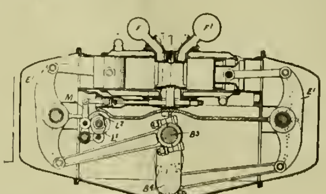
Patent 105,092.

### MEASURING PRESSURES IN ENGINE CYLINDERS.

105,092.—V. MICKELSEN, 172, Lancefield Street, Glasgow.—March 25th, 1916.—The mean pressures in the cylinders *a* of internal-combustion engines are indicated by means of an electric thermometric device which is provided with a pressure as well as, or instead of, a temperature scale. For example, thermo-couples fitted in each of the exhaust pipes *b* may each be connected at will through leads *c* and a switch *e* to the galvanometer or indicator *f*, which, as shown, is provided both with a pressure and temperature scale and with a single pointer.

### INTERNAL-COMBUSTION ENGINES.

105,095.—F. LAMPLOUGH, Trafalgar House, Waterloo Place, London.—March 27th, 1916.—The engine comprises a pair of cylinders with pistons in both ends, the pistons in one end driving a single crank B3 through a lever E1, and those at the opposite end driving in the same way an opposite crank B4. By uniting two

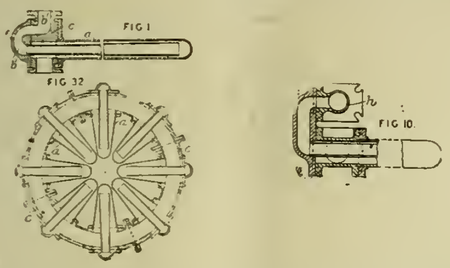


such engines with their contiguous cranks co-incident, a balanced engine is obtained. When used on flying-machines, a shaft mounted above the crank-shaft and parallel to it carries the propeller. A tubular slide valve, as is described in Specification 39/11, controls the passages leading from the admission pipe F and to the exhaust pipe F1. The valve is moved in opposite directions by cams L1, L2 respectively, acting through a lever M which is mounted on eccentric bearings to take up wear.

### STEAM-SUPERHEATERS, ETC.

105,103.—F. O. BYNOE, 51, Myrtle Road, Acton, London.—March 29th, 1916. Field tubes for superheaters have tapering inner tubes so arranged that the sectional areas of the steam passages gradually increase in the direction of flow. The outer tubes may

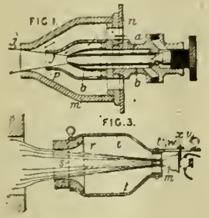
also taper. Field tubes with eccentric inner tubes are so arranged that the widest parts of the annular spaces between the tubes are in contact with the hottest gases. The tubes of the Field tubes may be replaced by similarly-arranged inner and outer chambers. The tube *a*, Fig. 1, opens into a header connector *c* having a flanged cap *f*, which places the inner tube in communication with the inlet passage *b*1. The cap may connect the inner tube




directly to the collector *h*, Fig. 10. The ends of the outer tubes are protected by removable caps of refractory material. A superheater may be built up of tubes *a*, Fig. 32, opening into headers *c* arranged in a circle. According to the Provisional Specification, the tubes are used for heating vapours and gases.

## LIQUID-FUEL BURNERS.

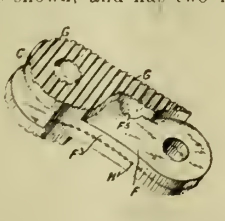
105,112.—H. F. HOVELER, Tandem Works, Merton Abbey, Surrey.—March 30th, 1916.—Liquid fuel supplied through a tube *a*, Fig. 1, is sprayed by steam, air, or gas from the tube *b*, and the sprayed jet *j* touches peripherally the outlet ends of intermediate and outer nozzles *p*, *m*, and a ring *r* Fig. 3, arranged between the nozzles and the furnace, boiler, oven, etc., heated. Air is induced




into the nozzles *p*, *m*, the supply being controlled by a rotary hit-and-miss regulator *n*, slidable valve, tap, etc. The refractory ring *r* is carried by a ring *s* attached to bars *t*, one of which is provided with a slot *t*1, in which the burner is supported adjustably by a nut *w* and a screw-threaded rod *x*. The whole apparatus is supported by chains secured to rings *u*. It is stated that the ring *r* allows of the production of a freely-burning flame without the assistance of an incandescent surface such as is described in Specification 6644/10.

## FURNACES; DRIVING CHAINS.

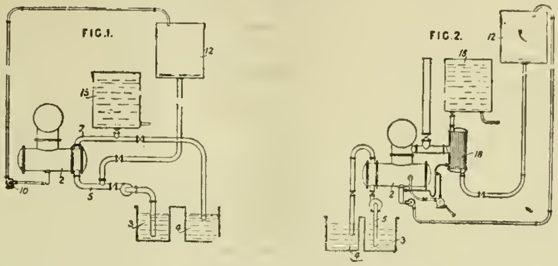
105,132.—W. J. COLE, Aberaman Gardens, Aberaman, Aberdare, South Wales. April 18th, 1916. A link for a chain-grate stoker is formed with a flat top and of such a length that there may be formed in the links and between the lugs C of connected links a series of air pockets or "boxes," from which air passes to the fuel bed. The pockets also receive the teeth of the driving-sprockets. Preferably, each link is made in two halves divided by a central plane, as shown, and has two lugs C at one end, a



central lug at the other, and a central flange F, which may have an aperture F5 to permit the circulation of air between adjacent pockets, and preferably has a concave lower edge F3 to enable it to work with circular supporting or like drums. Flutings G, H1 enable air to pass upwards to the fuel. The links may be formed so that the air pockets are formed one in each link, instead of half in adjacent links.

## HEATING BOILER FEED-WATER.

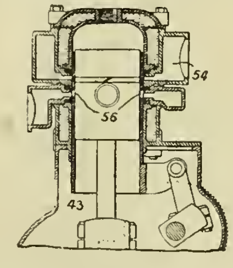
105,248.—R. BLACKMORE, Corporation Electricity Works, Stalybridge, Cheshire, and K. BAUMANN, Northwood House, Barnfield, Urmston, Lancashire.—March 9th, 1916.—In a condensing steam-power plant, the whole of the exhaust from one or more of the engines or turbines is condensed at suitable intervals during the normal running of the plant, by feed-water, either in the main condenser or in an auxiliary condenser, the flow of circulating water through the condenser being cut off. The cold-feed tank 12, Fig. 1, and the hot-well 15 are in valve-controlled communication with the pipes 5, 7 through which water is circulated through the condenser 2 from the culvert 3 to the culvert 4. A pump 10 delivers the condensed steam to the feed-tank. An auxiliary condenser 18, Fig. 2, may be provided for use exclusively as a feed-heater. Water is not circulated through the main condenser 2 when the auxiliary condenser is in use. The main condenser may be partitioned, one or more parts serving as an auxiliary for use in the manner described above. The condensers may be of the direct-contact type, and the feed-water may be passed through a condenser several times. The apparatus may




be provided with two hot-wells, the pipe connexions and valves being so arranged that water may be withdrawn from one of the wells for supply to the boiler, while the other well is being filled with condensed steam, and *vice versa*. In a further modification, the flow and return pipes for the feed-water are connected to the same tank, into which the condensed steam is discharged.

## INTERNAL-COMBUSTION ENGINES.

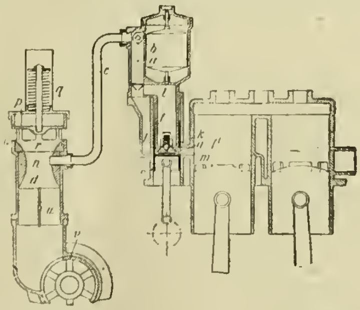
105,250.—R. HADDAN, 31, Bedford Street, Strand, London.—(Osborn Foreign Patents Co., Times Building, New York, U.S.A.)—March 30th, 1916. The charge is admitted through a port 56




uncovered by the piston at about half-outstroke, the port being closed by the sleeve valve 43 at the end of the stroke. The exhaust port 54 is uncovered by the end of the valve 43, which is laways subject to the pressure in the cylinder. A piston valve in a separate casing may replace the sleeve valve.

## INTERNAL-COMBUSTION ENGINES.

105,252.—W. MORGAN, 38, Wellington Road, and W. MILLS, Bridge Street West, both in Birmingham.—March 31st 1916.—In fuel-supply systems in which the fuel is delivered from a nozzle by a difference of gaseous pressures created by the engine through a conduit different from that through which the fuel thus delivered is conveyed by a pump, this pump, which does not affect the fuel delivery from the nozzle, is adapted to convey, not only the fuel, but also a quantity of gaseous carrying-medium therefor. The fuel is admitted through a nozzle *b* to a chamber *a*, in which a depression is produced through a conduit *c*, which enters a constricted portion *n* of a pipe *d*, through which atmospheric air is delivered to the crank chamber or other pump space, whence it is supplied to the cylinder. The area of the constriction *n* and of the nozzle *b* may be varied automatically and simultaneously. To ensure that a depression shall be produced in the pipe *d*, its inlet end *o* is provided with an automatic valve *p*, which is kept normally closed by a spring *q*, the pipe being provided also with a throttle valve *u*, and with a

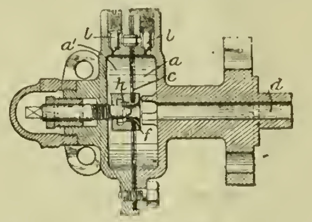


mechanically-actuated rotary valve *v* in the case of a two-stroke engine. The chamber *a* has a conical bottom, through a restricted aperture in which the fuel flows to a chamber *j*, whence it is drawn into the pump *e* and delivered, along with a gaseous carrying-medium such as air, exhaust, or other inert gas, through a port *m* into the cylinder *f*1. The carrying-medium may be admitted to the chamber *a* or *j* or to the pump. The inlet and outlet ports *f*, *g* of the pump are formed in the piston and are so situated that the suction and delivery are delayed and made more vigorous so as to facilitate mixing of the fuel and its carrying-medium. A relief valve *k* allows excess fuel and carrying-

medium to escape into a chamber *l*, whence it is returned to the pump inlet, the chamber *l*, in conjunction with the restricted orifice, serving also a damping-space to prevent disturbance by the pump of the pressure conditions in the chamber *a*. For this purpose also, the pipe *c*, at this junction with the chamber *a*, may be flared to ensure a low velocity of the entering air. The pump may be timed relatively to the engine piston, and whilst the engine is running. The fuel may be supplied by positive pressure, for example that of the exhaust gases acting upon the fuel in the float chamber. In a modification, the nozzle is situated in the air-pipe *d* and delivers fuel into a cup which faces the current of air, the mixture being passed through a vaporiser before entering the pump chamber. A vaporiser may be provided in the chamber *j* or in the conduit *m*. The fuel, with its carrying-medium, may be injected directly into the cylinder, as shown, after the main air admission ports have been closed, but before the piston has completed its compression stroke; or it may be injected into the induction pipe or into the transfer passage near the inlet valve. The non-pressure side of the pump may be in communication with the air-induction system to utilise leaking fuel. Multiple jets and chambers may be provided in the case of multicylinder engines. The Provisional Specification states that the fuel from the jet-chamber may be drawn directly into the cylinder through a valve, the opening of which is delayed to produce suction, or it may be led to the seat of a poppet valve and fed to the cylinder by the induction action of the entering air.

### VALVES.

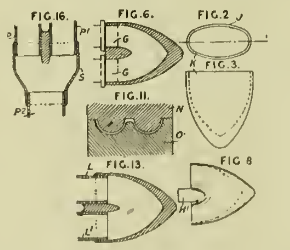
105,270.—F. W. MARILLIER, "Deva," Westlecott Road, and C. C. CHAMPENEY, 16, Goddard Avenue, Swindon, Wiltshire. April 18th, 1916.—Relates to valve apparatus for high-pressure gas supply, such as on railway carriages, for automatically cutting off the gas supply from the tank in the event of abnormal flow caused by such means as the fracture of a pipe leading to the burners.



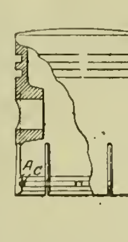
The valve is of the kind comprising a diaphragm *c* and a fixed adjustable valve member *h*. One side *a* of the diaphragm is connected at *d* to the gas tank, and the other side *a*1 to the burners. The diaphragm is fitted with a seat *f* and is centrally guided on the adjustable valve member by a clamping-nut *h*. Screw valve plugs *l* are fitted in each half of the casing to equalise the pressures on the two sides of the diaphragm after it has operated in an emergency and it is desired to re-open the valve.

### MAKING STEAM-SUPERHEATER ELEMENTS.

105,275.—G. D. PETERS & CO. Moorgate Works, Moorfields, London, and F. C. HIBBERD, Windsor Works, Slough, Buckinghamshire.—May 10th, 1916.—Return bends or connectors for steam-superheater elements are formed from solid pieces of iron, steel, etc., by dies which first bring the metal to the shape shown in plan and side view in Figs. 2 and 3 respectively. A further pair of dies force the sides J. K of the hollow forging towards one another, two cylindrical mandrels G being placed, as shown in Fig. 6, to form circular tube-receiving openings. The forging is finally cut away at these openings to a certain depth, leaving a solid middle portion H1, Fig. 8, which takes between the connected tubes. A modified mode of producing the bend consists in employing dies N, O, Fig. 11, which form halves, each as shown in Fig. 13, which are welded together and to the tubes L, L1. A further form of connector is shown at S, Fig. 16, being used to join two pipes, P, P1 to a tube P2. Dies as in the first-mentioned process are employed, and the bottom of the forging is cut off for the introduction of the tube P2.




Patent 105,275.



Patent 105,312.

### PISTONS.

105,312.—HUMBER LTD. and F. T. BURGESS, Humber Works, Stoke, Coventry. Nov. 18th, 1918. A piston of the kind described in Specification 100,706, having a bevelled bell-mouthed lower edge A adapted to exert a resilient scraping action as it descends, to remove surplus oil, when made of soft material such as aluminium alloy, is provided with a split expanding ring C located in a groove near the lower edge.

## INDEX TO ADVERTISERS.



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— THE —

# Industrial Engineer.

VOL. V.] AUGUST 8TH, 1917. [No. 140.

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Published twice monthly, on the 8th and 22nd days, respectively.

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# EDITORIAL.

## THE USE OF MOTOR CARS.

IT is, of course, self-evident to even the least observant individual that the use of motor cars has developed rapidly throughout the world during the last ten years. The industry of making cars has assumed large proportions, particularly in the United States, France, Great Britain, Germany, and Italy, but in no country has the advance been so rapid as in the United States. Here, in the first place, there is a great home market of nearly 100,000,000 people, who require to travel long distances, and can do so on the great trunk roads. In the second place, the usual ingrained instinct of the American to do everything he can by machinery is responsible in a great measure for the developments which have taken place. Coupled with these two factors is the production of cars of well-known type at reasonable selling rates, which give everyone with only a fair income the possibility of possessing a car either for pleasure or business. Under these and other circumstances, it is not, therefore, surprising to learn that there were 3,512,996 motor-cars in the United States in 1916, a gain of 1,067,332 cars over 1915, according to the Department of Agriculture, which also says that various States collected 25,865,369 dollars in registration and licence fees. The gain in number of cars in 1916 over 1915, 43 per cent, closely approximates the gain in number during the preceding three years, and it is worth noting that revenues have increased nearly 50 per cent yearly in the same period. The foreign trade department of the National Association of Automobile Manufacturers places the number of cars in the entire world at the close of 1916 at 4,216,943, so that the United States easily has 83 per cent of the entire world's supply of motor-cars. In other words, the United States has one car for every 30 persons, and a like proportion, if held in the world as a whole, would mean something like 56,000,000 cars.

The latter figure indicates the gigantic proportions to which the industry of car making can attain, though, of course, there is a certain amount of idealism about the figure total referred to, as there is a tremendous population which will never see a car, much less become the owner of one. Nevertheless, the United States figures above are indicative of what can be done, and they also show the general prosperity of its citizens. We wonder whether the war will have taught British makers what a vast number of people there are in this country who would purchase British-made motor-cars if they were produced at a reasonable price, and with a decent margin of power? It can be done. Of that, in our opinion, there is no question.

## ELECTRICAL MATTERS IN THE BRITISH WEST INDIES AND BRITISH GUIANA.

SOME interesting particulars are just to hand as to the imports of electrical goods in British West Indies and British Guiana. From these it would appear that although electricity has been introduced into Barbados, Trinidad, British Guiana, and Jamaica, for lighting, and as a source of power for tramways, it has not come into general use, and there is a wide field for its expansion for lighting and domestic purposes. For the whole of the West Indies and British Guiana the value of the imports of electrical apparatus and fittings amounts to only £35,000 a year. This, however, does not include machinery or the large quantity of copper wire required by the tramway, electric lighting, and telephone companies. The value of wire used considerably exceeds the value of electrical apparatus. Of the requirements for electrical goods of all kinds, the United States is at present the largest supplier, but the bulk of these goods came from the United Kingdom previous to the war. The United States has now practically all the trade of Trinidad and Bermuda, about two-thirds that of Jamaica, and more than half that of British Guiana. The United Kingdom comes next,

supplying the greater part of the trade of Barbados, about one-third of that of Jamaica, and practically all the trade of the Windward and Leeward Islands.

There are only three cities in the West Indies and British Guiana that have electric tramway services, namely, Kingston (Jamaica), Port of Spain (Trinidad), and Georgetown (British Guiana). It is understood that, after the war, the existing mule tramway system in Barbados will be replaced by an electrical system, the rails and some of the machinery required having already been imported.

Electric motors are being gradually introduced into the larger sugar factories, engineering establishments, and cotton ginneries, and also for dental and other minor purposes, where electric current can be obtained. In the last few years electric fans have been introduced in the principal commercial and public offices. In all the principal hotels and private residences electric bells are now fitted.

Throughout the larger islands complete telephone systems are to be found.

As regards the electrical fittings used in the West Indies, etc., it is to be noted that the electric lighting system in Barbados follows the British practice in using the bayonet type of fitting, but in British Guiana, Trinidad, and Jamaica, the American screw-base type is in use.

In the Windward and Leeward Islands electricity has not been introduced to any extent. Attempts to introduce electric cookers into the larger islands have, up to the present, met with little success.

## Trade Items, Notes, &c.

Messrs. Walter Somers and Co. Ltd. have placed an order for a 1,000 H.P. Parsons turbine, coupled to a Siemens 750 kw. generator, for installation in the power house at the Halesowen Forge.

The tender of Messrs. Macfarlane, Strang and Co. Ltd., Glasgow, has been accepted by the district committee of the Linlithgow County Council for about 360 tons of cast-iron water pipes and specials.

Magnesite.—The Quebec shipments of magnesite for last year reached 53,976 tons, valued at £105,193, as compared with 16,285 tons valued at £27,470, in 1915. Before the war the world's supply of magnesite for refractory purposes came from Australia.

Aluminium Pistons.—On the subject of aluminium pistons for internal-combustion engines Mr. Joseph Leopold, an American engineer, advocates a plain-sided piston of normal length, with circumferential grooves in the skirt, as distinct from the hour-glass or narrow-waisted type. It has only two rings above the gudgeon pin, the lower one having its groove bevelled and the bevel drilled through to the interior. A third ring is provided at the bottom end of the skirt.

Fuel Research Board.—Various questions of a technical character having recently arisen relating to the supply of gas, and the Fuel Research Board have undertaken, at the request of the Board of Trade and other Government departments concerned, to conduct an investigation and to advise them as to the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products, and the purposes for which coal is now used.

Enemy Businesses Wound Up.—Messrs. Kahn and Rothbarth, London agents of the Seitz Works, of Kreuznach, (Germany, and of other German manufacturers of gymnastic and electrical apparatus, etc., of Tower House, 39 to 40, Trinity Square, E.C., have been required by order of the Board of Trade to be wound up. The Controller is Mr. R. E. Smith, 53, New Broad Street, E.C. An Order has been made by the Board of Trade requiring the business of W. P. Theermann and Company Ltd., 283, Oxford Road, Chorlton-on-Medlock, Manchester, electrical engineers, to be wound up. Controller: William Eaves, 15, Fountain Street, Manchester.

Electrification of South African Railways.—The question of the electrification of the railways in South Africa has again been under consideration. On the recommendation of the Railway and Harbours Board, approval has been given to the engagement of an English firm to investigate and report upon certain sections of the South African railways system, with a view to enable it to determine what the capital outlay, involved in the conversion of steam working to electric power working, is likely to be, and whether the reduction of the cost of operation and the benefits to be derived by the public would justify the adoption of electric traction.

Peat for Fuel.—The Fuel Research Board, with the sanction of the Privy Council for Scientific and Industrial Research, has appointed a committee of inquiry into the utilisation of Irish peat deposits. The terms of reference to the committee are as follows: "To inquire into and to consider the experience already gained in Ireland in respect of the winning, preparation, and use of peat for fuel and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favourably situated localities, it can be profitably won, prepared, and used, having regard to the economic conditions of Ireland, and to report to the Fuel Research Board."

A Large Diesel-engined Motor Ship.—The largest Diesel-engined motor ship so far built in the United States is the twin-screw naval collier Maumee, of 14,500 tons displacement, propelled by two single-acting, two-cycle Diesel engines of 2,600 shaft horse power each. Each set of engines has six cylinders, 25·2 in. in diameter for a 37·37 in. stroke. At a normal speed of 130 revolutions the engines are designed to give the ship a speed of 14 knots. Since she was completed, last December, the Maumee has been in active service for five months, and during that time has made 18,000 miles. The consumption is about 0·5 lb. of oil per shaft horse power for all purposes.

Galvanised Iron Wire for H.T. Transmission.—The Connecticut Public Utilities Commission has agreed to the Central Connecticut Power and Light Company using galvanised iron wire for H.T. transmission on certain rural lines, on account of the high price of copper. It is proposed to use double-galvanised BB grade No. 6 iron wire, on poles spaced 250 ft. apart, sagging the wire to give a factor of safety of two with class B loading, viz., ½ in. coating of sleet on the wire and a wind pressure equalling 8 lbs. per square foot of exposed surface of wire and sleet, at a temperature of 0 deg. Fah. The iron wire is to be used where voltage drop will be inappreciable, and will be replaced with copper if it deteriorates so as to be unsafe.

The Government's Electrical Supply Scheme.—A circular letter referring to the Board of Trade Committee on Electrical Supply has been sent out by the Association of Municipal Corporations, stating that three witnesses have been nominated by the Association to give evidence before the Committee, these being from the City of Leeds and the boroughs of Blackburn and Sutton Coldfield respectively. The Association points out that the following, amongst other questions, will probably come under consideration: (*a*) The question of forming entirely new and large areas of supply and distribution, irrespective of existing municipal boundaries; (*b*) the question of the constitution of the managing body to deal with the supply in each of these areas. Observations which the Councils think would be useful for their witnesses to have are asked for by the Association.

Standardising Engines.—Many believe that some of our troubles in overcoming competition will be met by standardising in the engineering trade. Not only have strong efforts been made in this direction, but considerable progress has also been achieved. One interesting example relates to the model specification for cargo steamers' engines, introduced by the North-East Coast Institution of Engineers and Shipbuilders. The merits of this specification, with its modifications, is to be put to a practical test, Messrs. Furness, Withy and Co. Limited, having given a contract to Messrs. Irvine and Co., of West Hartlepool, for a large cargo vessel, which is to be fitted with engines designed according to the model specification, and made by Messrs. Richardsons, Westgarth and Co. Limited. It is satisfactory that their venture is to be made, and that three such eminent and experienced firms should be connected with it.

## WORKS ORGANISATION.

By A. W. Reeves and Cecil Kimber.

(*Concluded from page 389.*)

### Clearance to Destination.

The method of procedure in regard to this is rather interesting to note, inasmuch as the system provides, as far as humanly possible, the maximum of safety with the minimum possibility of goods being despatched without invoicing or checking, or to the wrong destination.

In practice the scheme works as follows:—

Assuming the finished goods have arrived in the Finished Stores, and that they are in accordance with both the Sales Order and Production Orders—copies of both being in the Stores' possession under the authors' arrangement—the Storekeeper makes out a Notification Slip. This, if necessary, can be in triplicate, one copy going to the Invoice Clerk, another copy to Sales Department (if distinct from the Invoice Clerk), and the third to the Schedule Department for recording on the Contract Schedule.

On receipt of the Notification or Clearance Slip, the Invoice Clerk types out at one operation a special sextuplicate set of forms, distributed as follows:—

(1) Forms the invoice to the customer, and this may be held back for pricing later, if desired.

(2) Is issued to the Accountants' Department.

(3) Forms the Sales Department reference copy.

(4) Forms a "Release Note" and is issued to the Forwarding Department, and is used as a voucher by the latter to collect the goods from the Finished Stores.

(5) Forms the "Consignment Note," and is issued to the Forwarding Department for enclosure with the goods. This copy may be sent separately as an advice to the customer, if so required.

(6) Forms the label for affixing to the package.

It is, of course, understood that the forms used are of different widths across in order that the typed prices only appear on those forms on which they are necessary. It is thus seen that it is impossible for the goods to leave the Finished Stores without an invoice being made out to cover such issue. The importance of this point it is hardly necessary to labour, as it will be apparent to all.

The routine to be followed in despatching goods and invoicing them up to the various departments of the Ministry of Munitions, the Admiralty and the War Office is not dealt with here, as in the opinion of the authors the conditions are artificial and not likely to continue after the War. Furthermore, the system required to deal with the clerical side of this class of work is now so well known to munition firms that there is hardly any need to dwell on it. However, it will not be found to interfere in its working with the scheme under discussion, but will merely supplement it.

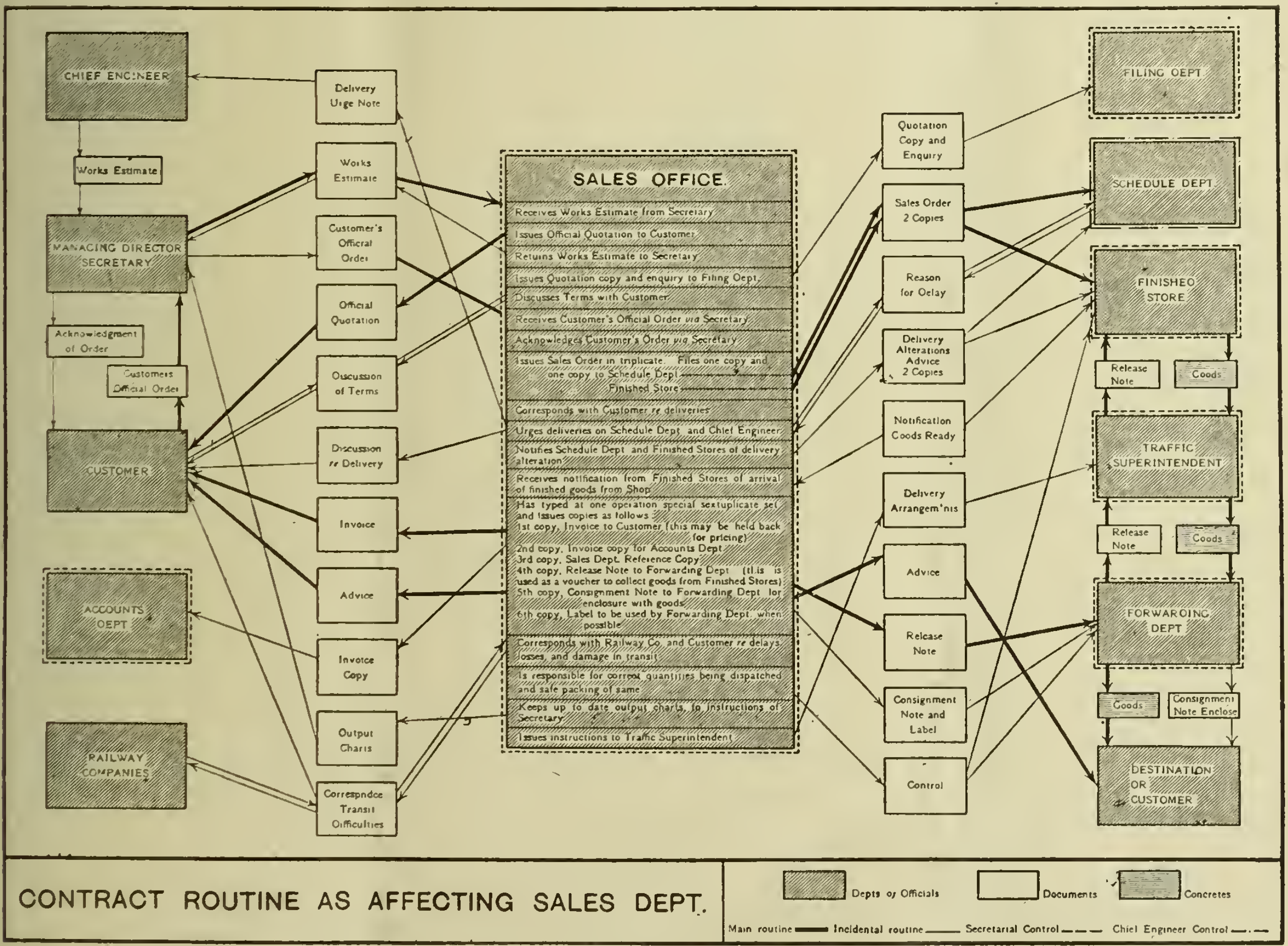


Fig. 11.—Works Organisation.

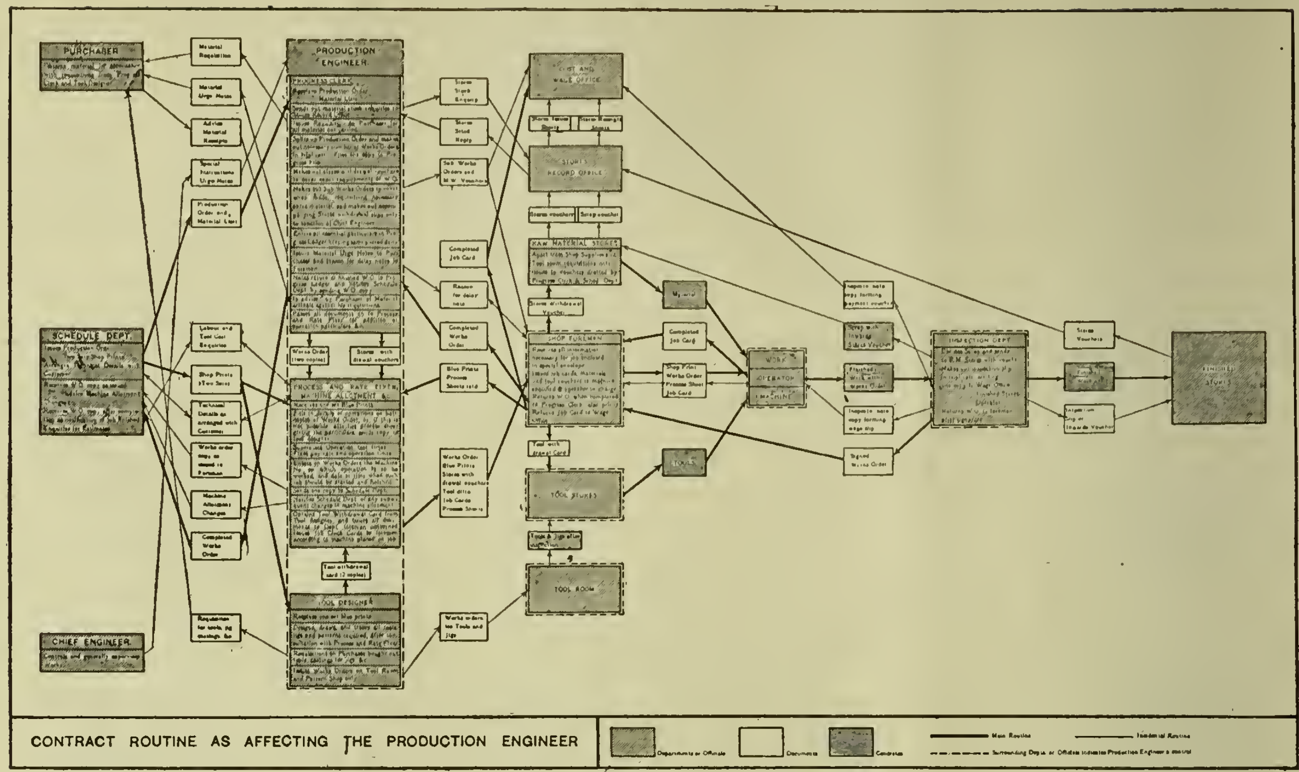


Fig 12.—Works Organisation. Routine Chart for Production Engineer and Allied Planning Departments.

## Incidental Routine.

Dealing with the incidental routine, it should be noticed how the Schedule Department will apply to the Production Engineer for labour costs, upon which the former will base the estimates. Technical details arranged with the customer subsequent to the order being placed would always be dealt with through the Schedule Department, and never direct with the Shop, but, if important, *via* the Chief Engineer. The Schedule Department will issue a note, if necessary, asking the reason for delay, and the Progress Clerk in his turn will ascertain from the departmental foreman why the job is being held up.

In the majority of cases tools will be made to a Production Order held by the Tool Designer, who will issue the necessary Works Orders on the tool room or pattern shop. The Tool Designer will also requisition on the Order Department for tools bought out and jig castings, etc.

It is interesting to note the manner in which the Cost and Wage Offices automatically collect the necessary information to give them the final costs of the job. It will be seen that the Stores Vouchers handed in either with finished work, scrap, or for goods, see Figs 8 and 9 *ante*, are passed along to the Stores Records Office, which in its turn collects all the information on sheets of the Stores Issues and Stores Receipts, passing it on to the Costs Office. The complete Job Card and Time Sheet having already been passed to the Cost and Wages Offices, as previously mentioned, this is all the information required from the Shop.

It will, of course, be understood that the Wage Office checks the total times clocked by any one operator on his

**CONTRACT SCHEDULE.** FOR MONTH ENDING..........

Customer.................... Customer's Order No..........

Sales Order No.......... Date.......... Deliveries required by..........

Prod. „ .......... Delivery rate..........

| Description of Part | Customers Part No. | D. O. Record No. | Number per Set | Number of Sets | Total Units Required | Made on Machine No. | Delivery Quantity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
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Actual number of units entered in squares. If delivery behind schedule entries to be made in red ink.

Fig. 13.—Works Organisation. Contract Schedule Form.

various jobs, and these are summarised in a Weekly Time Sheet, against the total time as shown by his Weekly Time Card.

### Concluding Remarks.

As mentioned at the beginning of the paper, it is impossible to go thoroughly into the countless details which will occur to everyone, in the time and space by which this paper is limited. However, the authors hope that sufficient matter has been presented to form a basis upon which an organisation which will be economical to work can be successfully founded.

The procedure outlined is that necessary to ensure that Shop activities have a definite ultimate aim, with the responsibilities of the operators and executives clearly defined, and to eliminate overlapping and duplication of effort.

In conclusion, it should be specially noted that the success or failure of an organisation of this description depends almost entirely upon the way in which it is adhered to by the managing heads. That is to say, that although in some instances it may be irksome for the latter to follow strictly the current routine, if they depart from the system as laid down and take "short cuts," they set an example which is bound to be followed by subordinates, and the result is chaos.

*(Concluded.)*

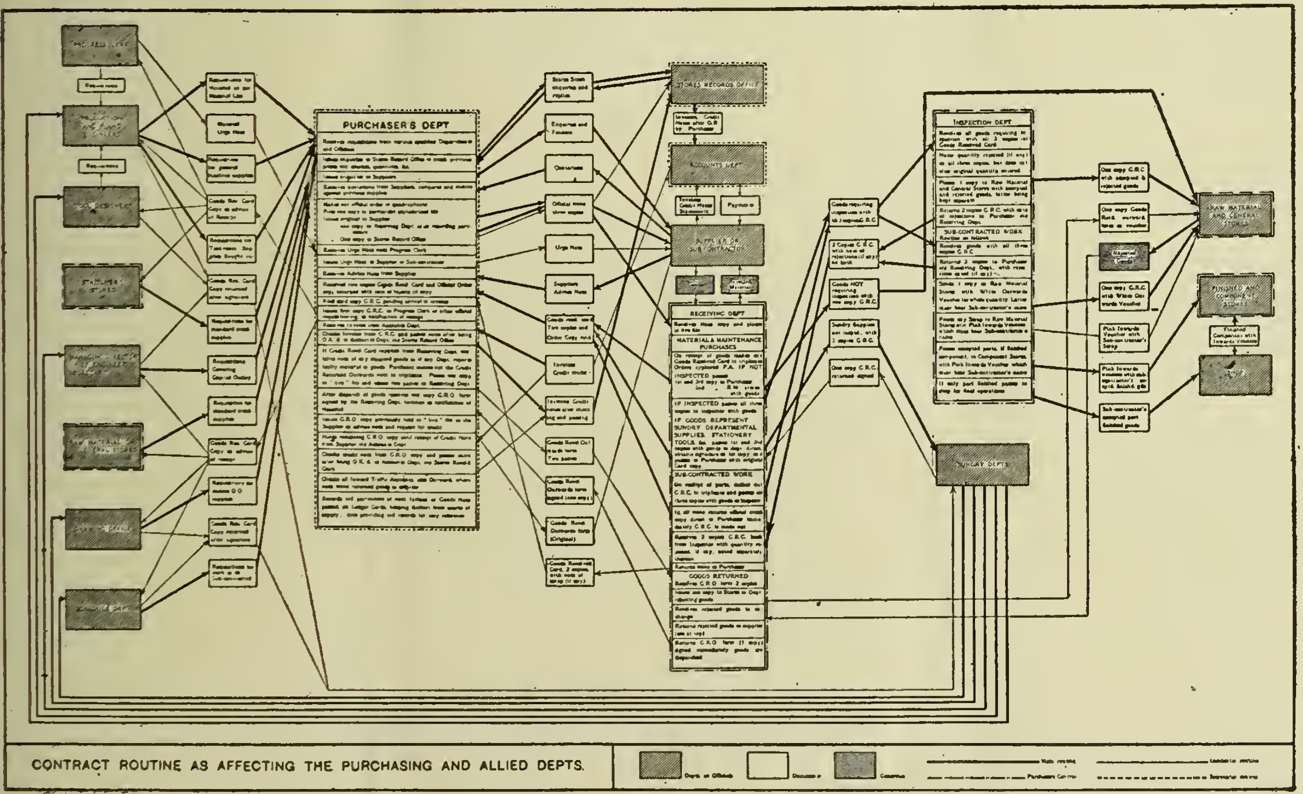



Fig. 14.—Works Organisation. Routine Chart for Purchaser and Allied Departments.

Lead Output of the U.S.A.—According to the *Iron Age* the prodution of primary refined lead in the United States in 1916 was 571,134 net tons, compared with 550,050 net tons in 1915, which is stated to be a record output. The primary lead available for consumption was 477,384 tons, an increase of 12 per cent over 1915, which is also a record. The exports of domestic lead in 1916 were 100,565 tons, against 87,306 tons in 1915 and 58,722 tons in 1914.

## MODERN STEAM TURBINES.

By J. Humphrey.

*(Continued from page 385.)*

### The Parsons' Steam Turbines.

Having discussed the general principles upon which impulse and reaction turbines work, attention may now be directed to the more practical side of the subject. The illustration (Fig. 4) shows pretty clearly the lines upon which a Parsons' steam turbine is built. A is the casing, which is made in two halves so that the top may be lifted and the rotor so exposed. B are the fixed blades, and C the moving blades. D is the rotating drum; E the dummy or balancing pistons which balance the end thrust due to the steam acting axially on the rotor blades. There are three of these pistons, and in order that they may balance the thrust they are put into connection with different stages of the turbine by means of the passages $F^1$, $F^2$, and $F^3$. Glands are provided at G, which are sealed with steam entering through the passages H. The bearings, which are shown at I, may be special flexible bearings or ordinary white metal bearings, according to the speed. J is a flexible coupling for connecting the turbine to the electric generator or blower, or whatever kind of machine the turbine drives. K is a thrust block for adjusting the axial position of the fixed blades, and for dealing with any slight end thrust that the balancing pistons do not compensate. To make this adjustment, a liner of the desired thickness is placed behind the thrust block so that the balancing pistons and gland rings may run as close to their fixed collars as possible without actually touching them. A worm on the rotor shaft meshes with a worm-wheel L and drives the governor and oil pump. Oil from the oil pump at the point M is supplied

to the bearings through the oil pipes N, passing on its way through the oil cooler O, which is constructed on the surface condenser principle, and the oil is cooled by means of water circulating outside the tubes. When the oil has passed through the bearings it returns to the oil tank on the opposite side of the turbine to that illustrated. Steam enters the turbine by way of the opening P, and then passes through the valve R to the governor valve S. The valve R is an emergency valve which shuts off the steam in the event of the speed exceeding a certain value. T is a feather which keeps the bearings, etc., central while the casing expands, and U is a set-screw for adjusting the top half of the end bearing and the thrust block which fits into it.

### Governing Steam Turbines.

Broadly speaking, there are four distinct methods of governing steam turbines, but the Parsons' turbine is usually governed on the blast principle. A double beat balanced valve S (see Fig. 5) admits steam to the turbine

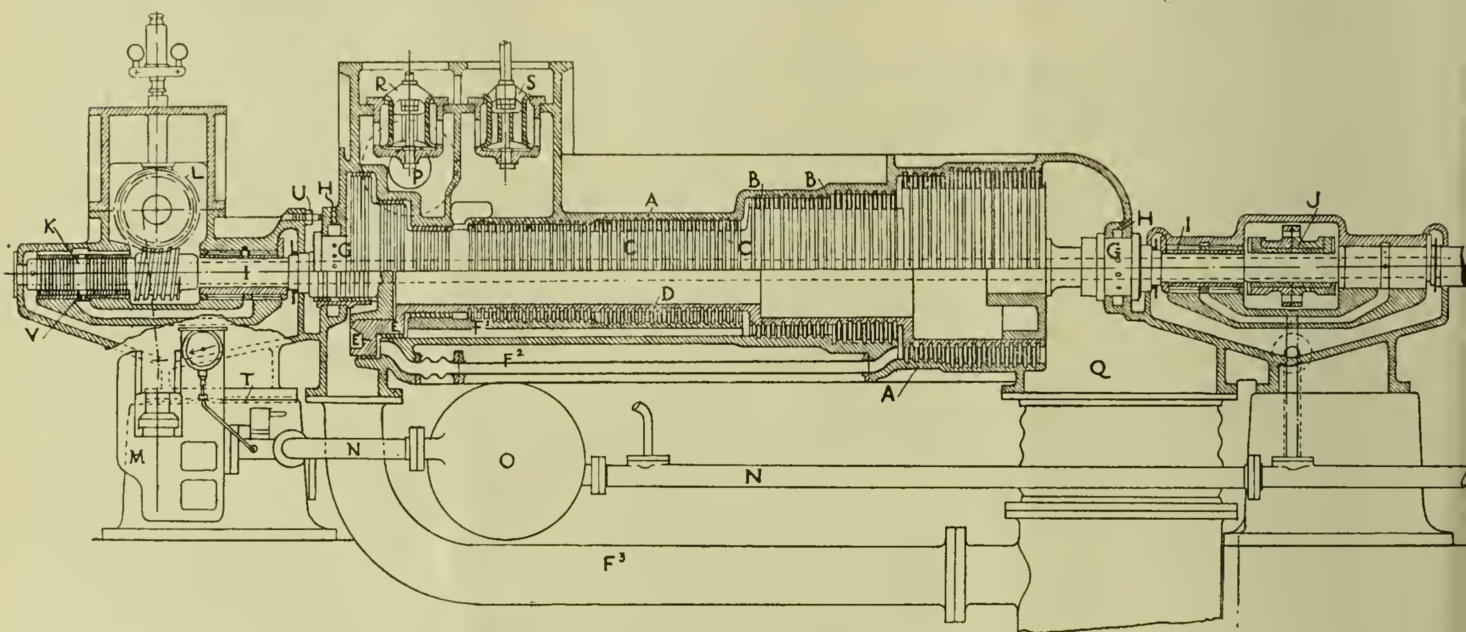



Fig. 4.—Section of a Parsons' Turbine.

in puffs of long or short duration, according to the load. When the load is heavy the valve opens for short periods, and remains closed during the greater part of the time, but as the load increases the period during which the valve is closed becomes shorter, and consequently the turbine receives more steam. The valve S is controlled by the governor through a steam relay, in which high pressure steam is continually admitted under the piston T, which is attached to the valve S by means of a spindle. On top of the piston T is a powerful spring which offers resistance to the piston being forced upwards by the steam beneath it. The quantity of steam which is admitted below the piston can be regulated by means of a small valve. On the right of the relay cylinder is a small round plunger U, which is caused to reciprocate by the lever V. When the plunger U is at one end of its stroke the steam is allowed to escape from beneath the piston; consequently the latter is forced downwards by the spring and the main valve S is closed. When the plunger is at the other end of its stroke, however, the exhaust part of the relay cylinder is closed and the steam pressure beneath the piston T rises, the valve S is lifted and steam passes into the turbine. Mechanism is provided for causing the relay plunger to reciprocate, and the governor alters the position of the plunger relative to the steam ports in the relay cylinder, so that at heavy loads the relay exhaust is closed for longer periods than when the load is light. This mechanism, however, will be described, together with other details such as bearings, etc., in a later article.

It is now common practice to mount the emergency governor on the same spindle as the controlling governor, and in the event of the speed attaining a value 10 per cent, or at the most 15 per cent, above the normal value, the governor releases a catch on the emergency valve, and the supply of steam is shut off from the turbine.

### Regarding the Advantages of Blast Governing.

As regards the advantages of blast governing, as the double-beat balanced valve is either wide open or closed, and never remains in an intermediate position for any length of time, there is no throttling, and the full benefit of the high-pressure steam is at all times secured. It is sometimes maintained that the times of admission of the steam into the turbine casing are far enough apart to allow the inside to be cooled by the drop in temperature between the puffs, and consequently when a fresh admission occurs the hot steam makes contact with the relatively cool walls of the casing, but probably this is more imaginary than real. Some turbine builders contend that the blast system of governing introduces unnecessary complications, and that a simple throttle valve will serve the purpose equally well, and some reaction turbines are fitted with governors of the throttle-valve type. That the blast governor is rather more complicated than the simple throttle-valve governor is, of course, perfectly obvious, but the additional parts associated with the latter give the charge engineer little, if any, more trouble. The actual amount of work that the governor has to perform in the case of the blast system is very small, because it only consists of controlling the small relay plunger. Moreover, the continual movement of the gear has the advantage of minimising friction. Some firms building Parsons'

turbines fit the blast governor while others fit a simple throttle valve. Moreover, in some cases a governor relay is used that is worked with oil pressure instead of steam pressure, and since the oil used for actuating the relay is the same as that used for lubricating the bearings, failure in the oil pressure results in the double-beat balanced valve being forced down upon its seat by means of the powerful spring above it, and the turbine therefore stops.

### Starting a Reaction Turbine.

When starting a reaction turbine such as that illustrated it is necessary, in the first place, to see that the emergency or running valve R is open. The stop valve is then eased off its seat, so as to allow steam to circulate inside the turbine casing. If a turbine is provided with an auxiliary oil pump, which is invariably the case when the main oil pump is of the rotary type, oil is pumped into the bearings by hand while the warming process is going on.

Some turbines, especially large turbines, are now fitted with independent oil pumps driven by a very small turbine, so that the oil can be set circulating through the oil ways before the rotor of the turbine begins to revolve. The oil pressure is registered on a pressure gauge to be seen just below the main bearing on the left of Fig. 4. On some of the smaller turbines and on some of the older types the oil is forced into the oil ways by means of a plunger pump; but on modern turbines, and particularly large turbines, the oil pump is usually of the rotary pattern.

When the oil has been pumped into the bearings a small valve on top of the turbine casing is opened, and this admits live steam to the neck glands. Under running conditions the exhaust steam from the governor relay passes into the glands, but during the starting period the quantity of this is insufficient for the purpose, and it is therefore necessary to supply a small quantity of live steam to prevent loss of vacuum. In order to maintain a good vacuum while the turbine is at work there should always be a little steam escaping at the neck glands. Another regulating valve is also provided for maintaining an equal supply of steam at each gland and a third valve for allowing some of the exhaust steam to escape into the atmosphere at times when the relay cylinder exhausts more steam than is necessary for packing the glands.

If the turbine runs non-condensing this third valve is opened wide before the machine is started, and kept open while running so as to allow the steam from the relay to pass into the atmosphere with as little obstruction as possible. It is, of course, unnecessary to pack the glands if the turbine is running non-condensing. When these valves have been adjusted, it is necessary to adjust the speed regulator on the governor so that when the stop valve is wide open the turbine does not run above its proper speed, and so cause the emergency valve to operate. This having been done, the main exhaust valve and main stop valve are opened when the turbine runs up to speed. Oil pressure is shown on the pressure gauge as soon as the rotor of the turbine begins to move.

### The Correct Oil Pressure.

The correct oil pressure varies somewhat with different turbines, but usually it is somewhere between 4 lbs. and 6 lbs. per square inch. When the turbine is working a little water is kept flowing through the oil cooler; otherwise the oil becomes overheated. It is desirable from the point of view of efficiency that a turbine should run at the exact speed for which it has been designed. The speed is usually read from a tachometer, but as these instruments are liable to give incorrect readings, especially when driven by a belt, it is desirable that the speed should occasionally be checked by other methods. When a turbine is fitted with a reciprocating oil pump it is a very simple matter to check the accuracy of the tachometer for the exact speed can be arrived at by counting the number of strokes made by the pump per minute, and this number multiplied by the reduction ratio of the pump drive, gives the actual speed of the turbine rotor. When a turbine is provided with a rotary oil pump, however, the tachometer has to be checked against the readings of a speed counter which is applied to the testing spindle on the tachometer.

### Testing the Emergency Governor.

Another thing that has to be tested regularly is the emergency governor. If for some reason the controlling governor does not work properly and the emergency governor fails to cut off the steam, in the event of excessive speed, then there is great risk of the turbine coming to grief, to say nothing of the damage that may be done by the flying parts. Very serious accidents have been known to happen as the result of turbines attaining excessive speeds. It is therefore important that the emergency governor should be tested periodically and preferably just after the tachometer has been tested. The speed is increased gradually by means of the governor regulator, until the excess 10 or 15 per cent above normal has been reached, or whatever speed the emergency governor is supposed to be set for, when the emergency governor should come into action and shut the turbine down. Sluggish action upon the part of the emergency governor is generally attributable to lack of freedom in some of the moving parts or levers that operate them, and cleaning and oiling are the remedies to be applied.

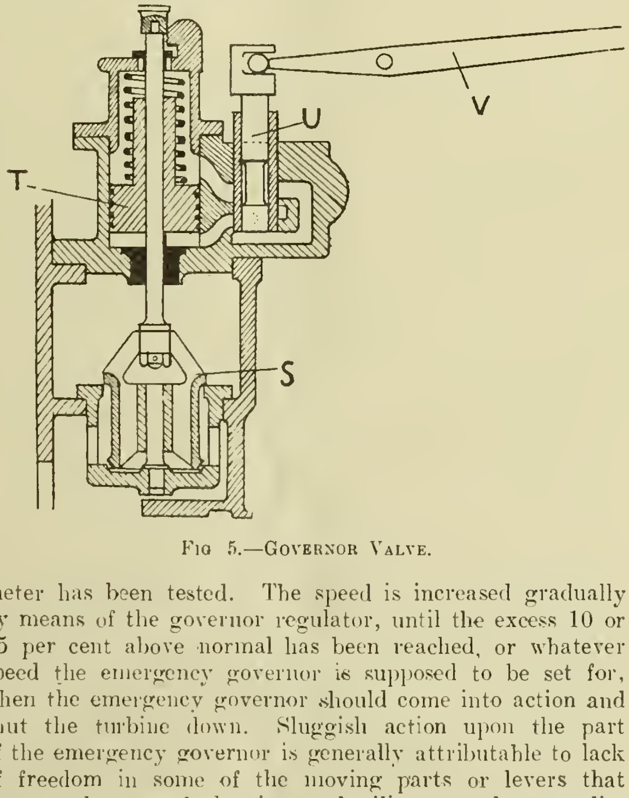



Fig 5.—Governor Valve.

### Hunting.

Hunting is a trouble seldom met with in connection with the steam turbine, but the controlling governor may nevertheless become somewhat erratic in its action. As a rule, this is attributed to the relay plunger having become dirty, with the result that it sticks slightly in the hole in which it works. The trouble, however, can usually be eliminated by removing the plunger and cleaning it with a piece of fine emery paper. These plungers are made of a special alloy with a very small coefficient of expansion, and they are very brittle. Great care is therefore necessary when handling them, for they are very easily broken.

The places where binding is occurring are usually indicated on the plunger, and to these places the emery paper should be applied. Lack of freedom in the governor dashpot may also be responsible for sluggish working. Governing troubles are also often due to bent rods associated with the governor operating mechanism, and to insufficient clearance at knuckle joints, etc. It is, of course, highly important that the governor valve S should be quite steam-tight when it is closed, and if there is reason to believe that it is leaking it should be removed and ground in.

When a turbine is running the amount of attention it needs is remarkably small. Careful attention should, however, be paid to the oil pressure, the steam pressure and superheat and vacuum. When the glands are packed with steam, which is the case on most Parsons' turbines, care should be taken to see that they receive an adequate amount; a little steam should always emerge from the glands at each end of the turbine. High vacuum is of great importance to the efficient working of steam turbines, and it is of the utmost importance that all joints on the exhaust side should be free from leaks.

*(To be continued.)*

## PLASTIC CEMENTS.*

By J. B. Barnitt.

It is to be understood that plastic cements cover that range of adhesives which are used to secure joints and connections between like or unlike material and which are of more or less permanent character. Physically speaking, plastic cements consist of a vehicle in which are suspended or dissolved solids of such nature that they are resistant to the gases and liquids coming in contact with them. In some cases the constituents of the cement react with each other or with the surfaces to which they are applied, thus forming a more strongly adhering mass. The prime object being in all instances to effect a joint of maximum strength, and in nearly all cases gas-tight, a few general instructions on the application of plastic cements are first given.

One of the principal precautions to be observed in the application of a cement is the condition of the material to be joined. All connections should be properly fitted together with flanges or exposed flat surfaces as nearly coincident as possible. The cement should never be depended upon to do what the pipes or other portions of the apparatus should do. Its function is to cement or seal and nothing more. In most cases one part of the fitting should overlap the other so as to make a small amount of the cement effective. Cement for a joint of this type should be of a nature that may be quickly applied, that is effective while in place and easily removed when desired. An excess of cement should always be avoided to prevent shrinkage, cracks, and leaks.

The general methods of plastic cement application are varied to suit special cases as follows:—

(*a*) Heating the composition to make it plastic until firmly fixed in place.

(*b*) Heat applied to the surface to be cemented.

(*c*) Application of the cement with water or a volatile solvent, depending upon the evaporation of the solvent for drying or setting.

(*d*) Moistening the surfaces to be cemented with water, oil, etc. (The vehicle of the cement itself.)

* From General Chemical Bulletin, Laurel Hill Laboratory, February, 1917.

(*e*) Application of the cement in workable condition, setting taking place by (1) chemical reaction, (2) hydration, (3) oxidation.

The application of the following materials as plastic cements is noted: (1) Plaster of paris; (2) hydraulic cement; (3) clay; (4) lime; (5) asphalte or pitch; (6) resin; (7) rubber; (8) linseed oil; (9) casein and albumen; (10) silicate of soda and oxychloride cement; (11) flour and starch; (12) miscellaneous materials.

### Plaster of Paris.

Plaster of paris is often used alone as a paste for joints on gas and wood distillation retorts and similar places where rapidity of setting is a requisite. In order to impart strength, a fibrous material such as asbestos is often mixed with it. Shavings, straw, hair, and cloth are frequently used as binders, when a high temperature is not required, while stone, glass, and various mineral substances are used as fillers. The following cements are particularly suitable for oil vapours and hydrocarbon gases:—

(*a*) Plaster and water.
(*b*) Wet plaster and asbestos.
(*c*) Wet plaster and straw.
(*d*) Wet plaster and plush trimmings.
(*e*) Wet plaster and hair.
(*f*) Wet plaster and broken stone.

### Hydraulic Cement.

Cement is used either alone or with sand, asbestos, etc., and is especially resistant to nitric acid. When used with resin or sulphur it is employed as a filler rather than for any powers of setting by hydration:—

(*a*) Cement alone.
(*b*) Cement and asbestos.
(*c*) Cement and sand.

### Clay.

This frequently enters into the composition of plastic cement as a filler. The finely divided condition of the material gives body to a liquid such as linseed oil which, unless stiffened, would be pervious to a gas, the clay being inert:—

(a) Clay and linseed oil is suitable for steam.
(*b*) Clay, linseed oil, and fireclay for chlorine gas.
(*c*) Clay and molasses for oil vapours.

### Lime.

Caustic lime and linseed oil mixtures are used as a putty. Chalk or china clay frequently replace part of the lime, but enough lime should remain to maintain the caustic property necessary to the formation of a certain amount of lime soap. Silicate and casein compositions also contain lime:—

(*a*) Lime and boiled linseed oil to a stiff mass.
(*b*) Lime, clay, etc., and boiled linseed oil to a stiff mass.

### Asphalte and Pitch.

Asphalte and pitch are used interchangeably in plastic cements, pitch making the stronger binder. Tar is of less value on account of the light oils and water contained in it. Asphalte in benzol is useful as an adhesive for uniting glass for photographic and microscopical uses, also for coating wood, concrete, brick work, steel, etc., where the melted asphalte would be too thick to apply readily. Benzol is the cheapest and most satisfactory solvent. For water-proofing, melted asphalte with a small amount of paraffin added, and in particular cases boiled oil, is used:—

(*a*) Refined lake asphalte.
(*b*) Asphalte, 4 parts; paraffin, 1 part.
(*c*) Asphalte, 10 parts; paraffin, 2 parts; boiled oil, 1 part.

Any of these may be thinned with hot benzol or toluol.

(*d*) Pitch, 8 parts; resin, 6 parts; wax, 1 part; plaster, ¼ to ½ part.

(*e*) Pitch, 8 parts; resin, 7 parts; sulphur, 2 parts; stone powder, 1 part.

Compositions (*d*) and (*e*) are used to unite slate slabs and stoneware for engineering and chemical purposes. Various resin and pitch mixtures are also used, the proportions determined by the consistency desired. Sulphur chemically prevents the formation of cracks while stone powder acts in like manner mechanically. If acid vapours or corrosive gases come in contact with the cement, limestone should not be the powder used, otherwise it is best. Wax prevents the composition from becoming brittle.

Plastic cements for caulking must be both tough and elastic, and have the added property of expanding and contracting with the joint to which they are applied:—

(*f*) Pitch, 3 parts; shellac, 2 parts; pure crude rubber, 1 part.

(*g*) Pitch, 1 part; shellac, 1 part; rubber substitute, 1 part.

(*f*) and (*g*) are mixed by melting over a burner.

### Resin, Shellac, and Wax.

A strong stone cement having little body and applied in layers.

(*a*) Resin, 8 parts; wax, 1 part; turpentine, 1 part. For nitric and hydrochloric acid vapours.

(*b*) Resin, 1 part; sulphur, 1 part; fireclay, 2 parts. Sulphur gives great hardness and permanency in resin cements.

Good waterproofing cements are:—

(*c*) Resin, 1 part; wax, 1 part; powdered stone, 2 parts.

(*d*) Shellac, 5 parts; wax, 1 part; turpentine, 1 part; chalk, 8 to 10 parts.

For a soft air-tight paste for ground glass surfaces:—

(*e*) Wax, 1 part; vaseline, 1 part.

A strong cement without body for metals (not copper), porcelain, and glass.

(*f*) Powdered shellac, 1 part; ammonia water, 10 parts. Allow to stand until solution is effected.

### Rubber.

Because of its toughness, elasticity, and resistance to alterative influences, rubber is a very useful cement.

As a leather cement:—

(*a*) Asphalte, 1 part; resin, 1 part; gutta percha, 4 parts; carbon disulphide, 20 parts.

As a resistant to acid vapours:—

(*b*) Rubber, 1 part; linseed oil, 2 parts; fireclay, 3 parts.

A plain rubber cement:—

(*c*) Cut crude rubber in small pieces and then add carbon disulphide or benzol, allowing the rubber to dissolve.

Corks and wood are made impervious to water by soaking them in the above solution.

### Linseed Oil.

Linseed oil is one of the most generally useful materials for cementing purposes.

For aqueous vapours:—

(*a*) China clay and linseed oil.

(*b*) Lime and linseed oil, forming the well-known putty.

(*c*) Red or white lead and linseed oil.

The above mixtures become very strong when set, and are best diluted with powdered glass, clay, or graphite.

(*d*) Oxide of iron and linseed oil.

### Casein, Albumen, and Glue.

Cements of this nature, if properly made, become very tough and tenacious, are resistant to moderate heat and oil vapours, but not acid fumes.

(*a*) Finely-powdered casein, 12 parts; fresh slaked lime, 50 parts; fine sand, 50 parts and enough water to make a thick mass.

A strong cement for ground unions standing a moderate heat.

(*b*) Casein in fine powder, 1 part; rubbed with silicate of soda, 3 parts.

(*c*) White of egg made into a paste with slaked lime. This should be used immediately after being made up.

A composition for soaking corks, wood packing, etc., to render impervious to oil vapours:—

(*d*) Gelatine, 2 parts; glycerine, 1 part; water, 6 parts.

### Silicate and Oxychloride Cements.

For oil vapours standing highest heat:—

(*a*) Paste of sodium silicate and asbestos.

For gaskets for superheated steam retorts, furnaces, etc.:—

(*b*) Sodium silicate and glass.

(*c*) Sodium silicate, 50 parts; asbestos, 15 parts; slaked lime, 10 parts.

A metal cement:—

(*d*) Sodium silicate, 1 part; oxides of zinc, lead, or iron, singly or mixed, 1 part.

(*e*) Zinc oxide, 2 parts; zinc chloride 1 part; water to make a paste.

(*f*) Magnesium oxide, 2 parts; magnesium chloride, 1 part; water to make a paste.

### Flour and Starch.

(*a*) Flaxseed makes a very tough cement, but does not withstand water.

(*b*) Flour and molasses to a stiff paste.

A permanent cement for ordinary temperatures impervious, but attacked by condensing steam and nitric vapours.

(*c*) Stiff flour paste and concentrated zinc chloride solution.

As a core compound:—

(*d*) Dextrine and fine sand

### Miscellaneous.

For insertion of glass tubes in brass or iron:—

(*a*) Litharge and glycerine mixed to a stiff paste.

For high heat:—

(*b*) Alumina, 1 part; sand, 4 parts; slaked lime, 1 part; borax, ½ part; water.

Core compounds:—

(*a*) Dextrine, 1 part; sand, 10 parts; water to form a thick paste.

(*b*) Anthracite coal powdered with molasses added to thick paste.

(*c*) Resin, partly saponified by soda lye, 1 part; flour, 2 parts; sand, 4 parts; with water as a diluent.

(*d*) Powdered glue, 1 part; flour, 4 parts; sand, 6 parts; water.

As a coating for glass ware to protect from injury by direct flame:—

(*a*) A mixture of fireclay and plumbago made into a paste with water.

For retorts:—

(*a*) Fine flour and lime, 1 part; potters earth, ½ part;

make a moist paste with white of egg well beaten with a little water.

For melting pots:—

(*b*) Sift brickdust and mix with equal quantity of red lead; rub together with boiled linseed oil, which has been mixed with sand to a stiffness of cement. In covering dishes apply the paste first then apply sand and heat.

(*c*) Put freshly slaked lime with concentrated solution of borax, apply with a stiff brush, and allow to dry. Upon heating a fused glaze is obtained.

For large pots:—

(*d*) Litharge, 6 parts; fresh burnt lime, 4 parts; white bole, 2 parts; and mix with cold linseed oil.

## THE SPLIT-PHASE MOTOR.

By F. S. Dellenbaugh, Junr.

It is difficult to realise, now that single-phase motors are manufactured by the hundred thousand, that not many years ago they were considered an engineering curiosity, and even after coming into practical use were uncertain in action. To understand why this type of motor is called "split-phase" and why a switch is necessary, its early development must be understood. To Tesla belongs the credit of conceiving the ideas leading to the experiments which resulted in the first successful induction motor. The first alternating-current motor was a two-phase machine, which was built after he discovered that the proper arrangements of windings upon the starter for each of the two phases resulted in a whirling flux. Any conductors in this whirling field are dragged around very much like leaves in a whirlwind. This principle of a revolving magnetic field is the basis for the operation of all induction motors. It is necessary to have two sources of magnetising current having a difference of phase in order to produce this rotating field. Therefore it was with considerable surprise that Tesla accidentally discovered that his two-phase motor would continue to run if one phase were disconnected after it has reached full speed. In other words, he accidentally obtained the first single-phase motor.

Although it was not clear at the time just why the motor ran, later it was discovered that the magnetic reaction of the rotating parts furnished the second magnetising current which produced the rotating field. This second component of the magnetising field is absent when the motor is not moving; an oscillating instead of a rotating effect is then the only result. Evidently this gives zero starting torque, and therefore the next problem was the development of some means of starting this newly-discovered single-phase motor. The most obvious method of starting the machine was to employ some external device which would give two-phase characteristics to a single-phase power circuit. This actually was done by means of a device called a "phase splitter," consisting of two independent circuits connected to the same single-phase line. One of these circuits contained a condenser, and hence had a leading power-factor, while the other included an inductance coil and had a lagging power-factor. When connected to the two windings of a two-phase induction motor, these two circuits gave approximately the same effect as a two-phase current, and would start the machine with somewhat reduced torque. After the motor was up to speed, one motor winding was disconnected and the phase-splitting device was cut out of the circuit.

This system worked satisfactorily, but was never tried out on a large scale commercially, because the phase-splitter was large and expensive, required hand operation, and did not give very large starting torque. The installation of the phase-splitting device in the motor itself was the next step. Engineering development finally produced the present design, in which two windings are still employed with the same mechanical relations to each other that are used in the two-phase motors, but having quite different electrical characteristics. The one winding has a low resistance and a high reactance, while the other has a high resistance and a low reactance. The result is that the power-factor is much closer to unity in one winding than in the other, and the phase displacement is sufficient to give the required whirling magnetic effect, resulting in a starting torque. The high-resistance winding, called the starting winding, if allowed to remain in the circuit, will generate enough heat to destroy the insulation. This heat is the direct result of the high resistance, but if the resistance is lowered the starting torque is proportionally decreased, and at best is only equal to full-load torque. The necessity for removing the starting winding from the circuit as soon as possible is inherently unavoidable in the design of this type of motor. Since the point at which this winding should be disconnected corresponds to a definite point on the speed-torque curve, the obvious way of producing the desired effect is by a centrifugally-operated switch. This is the scheme that was adopted, and it has been developed to a very high state of perfection.—*The Electric Journal.*

## THE SCIENTIFIC CUTTING OF METALS.*

By A. L. Deleeuw.

The rapidity of progress of the various branches of engineering may be said to be in proportion to the ease with which their principles can be reduced to mathematics. This was never so clearly shown as in the case of the development of alternating-current apparatus. Alternating-current apparatus has known no period of experimentation. Compare this with the slow, hesitating development of the steam engine in its first stages. In that case nothing was known except that steam would exert pressure. No knowledge existed of the properties of steam, or thermo-dynamics, nor of the mathematics of engineering materials. The moment that the fundamental facts of thermo-dynamics were understood and were reduced to mathematics, the progress of the steam engine became more rapid.

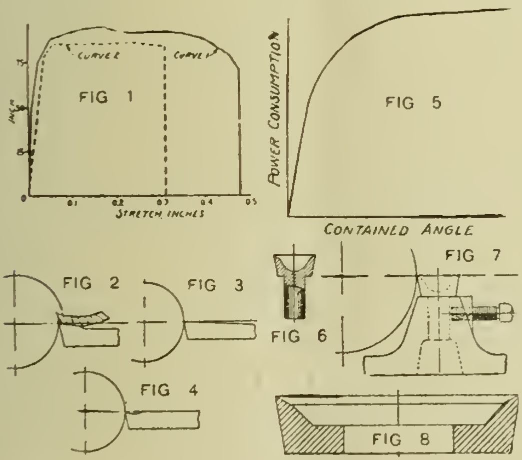
What are the things we should know about tools and machine tools to enable us to make these important servants of our present-day civilisation follow the line of development which the steam engine has enjoyed? Two stress diagrams of cold-rolled steel are shown in Fig. 1, of which one specimen had a tensile strength of 95,000 lbs. and an elongation in 4 in. of 12 per cent, and the other a tensile strength of 85,000 lbs. and an elongation in 4 in. of 7·4 per cent. The area of both pieces was ½ in. square and the length between gripping jaws 2 in. The amount of work done in separating the first piece was 3,500 foot-pounds per square inch of section, and for the second piece 2,000 foot-pounds per square inch. In parting the pieces the same result was obtained as if half the piece were removed by means of a cutting tool. Of course, this way of removing metal does not permit of controlling the shape or the finish of the remaining piece; but a certain amount of metal has been removed as effectively as if it had been done with a cutting tool. If this amount of metal had been removed by a cutting tool used in one of the present-day machine

* Abstract of paper read before the American National Master Tool Builders' Association.

tools, the amount of power required to do this work would have depended on the quality of the tool and the nature of the machine, but in no case would it have been less than $\frac{1}{4}$ H.P., assuming a reasonable time element.

If the only function of a machine tool were the removal of metal, we would find that our best machine tool has an efficiency of from 0·12 to 0·22. Even the better of these figures is very low compared with the efficiency of other machines. If chips could be removed from a piece of work by a straight pull, the ideal machine tool would be one which would remove material with the same amount of power expenditure as that required by the testing machine. While we would not expect to obtain such efficiency in practice, we would certainly aim to reach a much higher efficiency than we are able to obtain now.

So far as is known, no experiments have been made which establish the true nature of the cutting of metals with a reasonable certainty. In "The Art of Cutting Metals" and elsewhere diagrams are shown of the supposed action of a cutting tool. These are shown in Fig. 2. The writer believes that these diagrams represent a very good first guess; but he wishes to point out that this guess is not based on anything better than the inward vision of the authors of these various works. If this guess is correct, then the act




of cutting metal is a removal of the chip by tension, and the amount of power consumed for cutting should not be more than that required by the testing machine. If this is so, the total wastage of power in all the machine shops of the world is enormous; and it certainly would be worth while to investigate this matter thoroughly, merely from the standpoint of the conservation of energy.

Among the questions which should be answered before we can design machine tools in a thoroughly scientific manner are the following:—

When we turn up a narrow disc by means of a square-nosed turning tool, of which the width is greater than the width of the disc, is the action of removing the chip purely a matter of tension?

Does the front end of the tool have any function at all?

How far from the edge of the tool is the point where the chip strikes the tool?

If the action is purely a matter of pull, and the chip does not strike the top of the tool at the cutting point, but some distance farther back, then is it necessary that the cutting edge of the tool be sharp?

What is the nature of the lamination of the chip?

How much power is required for the actual removal of the chip, for the friction between chip and tool, and how much for laminating the chip?

What would be the best shape for such a turning tool for laminating the chip?

How does the amount of power vary with the various angles of the tool?

If the turning operation is not as simple as assumed in the first question, if, for instance, there is a side feed, such as in ordinary shaft-turning operations, how is the cutting action modified by this side feed?

If the chip is removed by the action of the top of the tool—that is, if the front of the tool has no function, then what determines the nature of the finish of a cut?

In what relation does the power required for the side feed stand to the power required for the actual removal of the chip?

As dark a subject as the action of the tool itself is the action of a cutting lubricant. It is a well-known fact that the use of a lubricant and the nature of the lubricant used affect both the finish and the size. A very pertinent question which might be asked is this: If the chip is laminated by tension—that is, if the point where the chip begins to separate from the work is some distance ahead of the point of the cutting tool, how can the cutting lubricant affect either size or nature of finish?

The writer had occasion to look into this matter when trying to determine the best cutting lubricant for automatic screw machines on small and medium-sized work. The lubricant in use was a mineral oil with 15 per cent lard oil. A certain job was selected, for which a form tool was used, and 24 screws were made with the regular compound. The screws came true to size within the limit of one-half of one thousandth. The oil was then removed from the machine and machine and tools were cleaned. The cutting compound to be investigated was substituted and another 24 screws were made. These screws were all larger than those cut with the regular oil Furthermore, they varied from two and one-half to five thousandths over size. The machine was once more cleaned, and the original oil put back. The screws again came uniform and to size, showing that the cutting of the first 24 screws had not dulled the tool or caused any other disturbing element to enter into the equation. The fact that the cutting compound caused the screws to be oversize might possibly be explained by a difference in heating or cooling effect of the different lubricants; but how can the difference in size of screws made with the same lubricant be explained, when there was no such difference with the use of the oil?

To be of value, the results of serious experimentation should lie in the direction of saving of power, diminished wastage of tools, and less strain on the machine, or in the direction of increased output, with or without the other advantages. That such advantages may be reached seems clear, and the author wishes to outline some isolated experiments, which, though not complete in themselves, point to very interesting possibilities.

Forged spindles of 60-point carbon steel were roughed by a tool shown in Fig. 3. As a rule, the tool was able to rough three spindles before a breakdown. In its broken-down condition the tool appeared as shown in Fig. 4. A hollow had been ground out by the chip, but a band of a little more than $^1/_{64}$ in. in width had been left at the front end, showing that the extreme front of the tool had not been in action. The experiment consisted of carefully measuring the broken-down tools and making new tools of just that shape; in other words, a tool like the old tool, but with a hollow ground in the top of the same shape, size, and location as in the old tool. This tool is shown in diagram in Fig. 4. The hollow was carefully polished, and a tool thus prepared would rough from nine to 13 spindles.

Examination showed that the hollow in the tool would remain smooth almost to the last, and that a complete breakdown followed very soon after the surface of the hollow began to show scratches. No tests of power consumption were made, but it may be expected that the power required with the old tool was more than with the new tool, as the chip did not have to bend so sharply and as the work required for hollowing out the tool was omitted. Another interesting point about this tool was that the actual contained angle between the front of the tool and the front of the hollow was much less than we would have dared to make between the front and top of an ordinary lathe tool, especially if this lathe tool were to be used for roughing. Nevertheless, under the conditions given, this tool, with the small front angle, stood up better than the original tool with the large angle.

In "The Art of Cutting Metals," Mr. Taylor stated that his experiments showed no perceptible difference in power consumption for various contained angles of the cutting tool. The writer thought that this conclusion would probably be correct only for the range of cutting angles tried by Mr. Taylor. He imagined that the relation between contained angle and power consumption would probably be a curve of the nature of Fig. 5, and that all the experiments made by Mr. Taylor were within the horizontal part of the curve. Experiments with angles much below the angles mentioned in "The Art of Cutting Metals" were made. Realising that an ordinary lathe tool would not stand up with much smaller angles than those used in present-day practice, the tool shown in Fig. 6 was designed. This tool is a body of revolution, and was held in a rigid block of metal, and directly over the lathe carriage. Fig. 7 shows the arrangement of tool and tool holder used. The tool was used for turning, preparatory to grinding, milling machine overarms, about $4\frac{1}{2}$ in. diameter and 5 ft. long. When the tool gave out, it was turned in the tool holder so as to present a new piece of the edge to the work. In this manner from 12 to 16 settings could be made with one sharpening of the tool. The sharpening itself was a matter of circular grinding. The tool would make a very smooth cut and without a steady rest would turn half the length of the bar with a variation in diameter of less than 0·003 in. The surface of the work was unusually smooth, and the amount required for grinding was much less than usual. Unfortunately, the lathe on which this work was done was too large and heavy to make accurate power readings for so slight an amount of power consumed, the cut being only $^3/_{16}$ in. reduction in diameter and with a feed of $^1/_{16}$ in. to $^3/_{32}$ in. The action of the tool was peculiar, and did not give one the impression that metal was being cut. This matter of the relation of the contained angle to the power consumption for a given cut had previously led to the introduction of the helical cutter, where the actual angle of the tool is not small, but where the tool is presented to the work in such a manner as to have the effect of a small angle.

Another experiment, more or less related to the same question, was an attempt to use a rotary lathe tool, such as shown in Fig. 8. The edge of this tool would bear up against the work, so as to have a very slight difference in speed between the work and the tool, and it was further set in such a way as to make the virtual cutting angle very small. The result was that it became possible to use very high cutting speeds without any apparent effect on the tool. The cutting speed was limited by the machine only. With a reduction of $^3/_{16}$ in. diameter and a feed of 12 to the inch, a cutting speed of 650 ft. was used for cast iron as well as for steel. All cutting was done dry. The chips made by this tool were not broken up and were practically solid steel bars. Furthermore, the chips as they came off the lathe were cold enough to be caught in the hand. It is, therefore, very likely that a test would have shown a remarkably low power consumption.

Though the foregoing experiments are incomplete in themselves, they show that there are great possibilities before us, and, further, that these possibilities lie away from the present-day shop practice. An instrument should be built, somewhat along the lines of a microtome, in which a soft material is to be cut by a razor-like blade or tool. This tool should be arranged so that it can present various angles to the work, and tools of various contained angles should be examined. The angles presented to the work should vary as to angle of clearance, angle of rake, and angle of shear. A dynamometer, which should be part of the instrument, should register the pull required for the cut. The material to be cut should be standardised, and it is suggested that paraffin may fill all requirements; by selecting a paraffin of standard melting point we would also get a material of standard hardness. In this manner the relation between cutting angles and power required could be established over a very wide part of the curve. Though the actual figures obtained would not be immediately applicable to metal cutting, it would make it possible to find the controlling law, and this done, it would then be possible to investigate the cutting of harder materials over a small portion of the curve and compare this portion with the corresponding portion of the curve already obtained. The same instrument could possibly be used for tests on such materials as lead, soft white metal, etc.

Another line of experimentation would be to arrange some machine tool, such, for instance, as a lathe, for running at very low speed, say, 1 in. per hour, mount a steel disc on this lathe, and take a cut at the circumference of this disc. In this manner the cutting action would be of the simplest kind, as the tool to be used could be a square-nosed tool of greater width than thickness of the disc, so that there would be no side cut. A moving picture taken at a high rate of speed could then be reeled off at a low speed, and it would probably be possible in this way to visualise what actually takes place in cutting metal. It would readily show whether cutting is merely the result of tension, or whether shear plays a rôle, or whether both are responsible. It would probably show whether the chip leaves the work ahead of the tool point, and whether or not the front end of the tool is in contact with the work. The writer believes that the time has come to try to interest as many engineers as possible in the subject of collecting fundamental data in regard to the cutting of metals.

## TAR OIL FUEL AND DIESEL ENGINES.*

The honorary secretary of the Diesel Engine Users' Association, Mr. Still, has suggested to me that a paper, or summary, or some form of connected statement dealing with the experience gained up to the present by members of the association in connection with the use of tar oils as fuels for their Diesel engines, will be of service at this juncture. The subject was first introduced to us in a practical form by Mr. Charles Day in January, 1916. Since then progress has been made in the problem of adapting our engines for the use of tar oils, and sufficient reliable information is now available to enable a survey to be attempted. True, the experience gained is not very

* Paper read by Geoffrey Porter, A.M.Inst.C.E., before the Diesel Engine Users' Association, May 24th, 1917.

extensive, but it is a useful practice to take the earliest practicable opportunity to study the results of pioneering work, in this instance, pioneering so far as Great Britain is concerned. This is my excuse for appearing before you to-day. With us the adoption of an oil fuel other than residual petroleum oils or shale oils has not recommended itself until comparatively recently, owing to the favourable terms on which we have been able to obtain imported residuals. But the force of necessity has compelled us during this period of war to look elsewhere for fuel supplies. Such sources exist in the coal deposits of our own richly-endowed land, and they are being brought into utilisation by native talent and skill which, as often before, have proved themselves in an emergency the equals and more of the best the world can offer. It is not impossible that we are on the eve of freeing ourselves from our former dependence upon other countries for supplies of suitable fuel oils, and I hope the country will arise the stronger from her present difficulties with one more market firmly established within her own boundaries. Members of the association will no doubt be able to take an active part in the development of the use of tar oils, and in so doing perform good service for our beloved country.

In the remarks I have to offer for your consideration, I propose to deal first with tar oil specifications and the quality of the oils offered by distillers; and, secondly, with facts observed and inferences to be drawn from actual experience.

In Table I. I have set out the figures obtained by several of our members who have submitted to analysis samples of the tar oils supplied to them. The tests were carried out by qualified analytical chemists. Mr. Day and Mr. Batho have quoted specifications for tar oil which may be regarded as standard. These specifications I incorporate at this point, together with the specification drawn up by the well-known M.A.N. Co., of Germany. Comparisons can readily be made by means of the table between the several specifications and the samples tested.

(1) Specification of the M.A.N. Co. :—

The tar oil must be a distillate of coal tar.

The oil must flow freely at 61 deg. Fah., and on being cooled down to 46·5 deg. Fah. and resting in a place undisturbed by vibration no separation shall take place at this temperature within the space of half an hour.

The following constituents shall not be present in quantities greater than the stated percentages:—

Ash .................. ·05 per cent.
Sulphur ............ 1·0 ,,

Proportions of water and coke residue not stated.

Per cent insoluble in Xylol 2.

(2) Continental specification for tar oil quoted by Mr. C. Day in his paper on "Tars and Tar Oils as Fuel for Diesel Engines" (January 19th, 1916):—

Tar oils must not contain more than a trace of constituents insoluble in Xylol.

The water content should not exceed 1 per cent.

The coke residue should not exceed 3 per cent.

At least 60 per cent of the oil should be distilled on heating up to 300 deg. Cen. (572 deg. Fah.).

The net calorific value should not be less than 15,840 B.T.U.'s per pound.

The open flash point must not be below 65 deg. Cen. (143·6 deg. Fah.).

The oil must be quite fluid at 61 deg. Fah.

(3) Specification of tar oil proposed by Mr. C. Day (January 19th, 1916):—

The tar oil must be a product of the distillation of coal tar. No product that has not undergone distillation must be present.

Per cent insoluble in Xylol ... not more than 2·0.
,, Ash ................. ,, ,, 0·08.
,, Water ................. ,, ,, 2·5.
,, Coking residue ..... ,, ,, 3·0.

The oil must be liquid at 60 deg. Fah. when maintained at that temperature for half an hour.

In case of crystals settling in the transport tank the buyer to be allowed to drain off the liquid portion and to return the solid to the seller.

Mr. Day pointed out that the calorific value of tar oils

Table I.—*Specifications for Tar Oils, and Results of Tests of Tar Oils, supplied to Members of the Diesel Engine Users' Association.*

| | Flash Point °F. | Specific Gravity | Water Content % | Sulphur Content % | Ash Content % | Coke Content % | Tar Acids % | Calorific Value B.T.U.'s per lb. G.—Gross Value. N.—Nett Value. | Content in-soluble in Xylol % | Distilling below 610°F. % | Loss at 220°F. % | Vis-cosity. | Setting Point, &c. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. M.A.N. Co.'s Specification | .. | .. | .. | below 1% | 0·05% | .. | .. | N—16,000 | 0·2% | .. | .. | .. | 46·5°F. |
| 2. Continental Specification (Mr. C. Day) | 143·6°F. | .. | 1% (max.) | .. | .. | 3% (max.) | .. | N.—15,840 (min.) | a trace | 60% at 572°F. | .. | .. | Fluid at 61°F. |
| 3. Mr. C. Day (19th Jan., 1916) | .. | .. | 2·5% | .. | ·08% | 3% | .. | .. | 2% (max.) | .. | .. | .. | Fluid at 60°F. for ½ hour. |
| 4. Mr. Batho (23rd Feb., 1916) | 100° to 130°F. | 1·0 to 1·1 | 1% (max.) | 0·5% to 1% | 1% (max.) | .. | .. | N.—15,800 to 16,500 | .. | .. | .. | 2° Engler | .. |
| A. Test of oil supplied | 190·4°F. | 1·039 at 60°F. | 0·4% | 0·58% | 0·03% | .. | 10·0% | N.—16,234 | .. | 65·6% | .. | .. | .. |
| B. Ditto | 169°F. | 1·033 at 70°F | 0·2% | .. | Nil | 2·61% | 14·0% | N.—16,475 | .. | .. | .. | 103 Redwood at at 70°F. | .. |
| C 1. Ditto | .. | 1·057 at 60°F. | 3·70% | 1·99% | 0·21% | 4·77% | Nil | N.—16,484 | 0·89% | 72·4% by weight | 16·10% | 103 Redwood | .. |
| C 2. Ditto | 197°F. (open) | 1·0525 at 60°F. | 2·9% | 2·12% | 0·02% | 8·39% | trace | N.—16,532 | 0·48% | 72·10% | 14·8% | at 32° F.—121 secs. at 70°F.—70 secs. | .. |
| D. Ditto | .. | 1·0326 | ·83% | ·73% | ·07% | .. | .. | G.—17,080 | .. | .. | .. | .. | .. |
| E 1. Ditto | .. | 1·065 at 61°F. | 1·00% | 0·5% | 0·2% | 3·0% | .. | N.—16,637 | .. | .. | .. | .. | Hydrogen, 6·8% Oxygen and Nitrogen, 2·4% Carbon, 90·1% |
| E 2. Ditto | .. | .. | 11·0% | .. | .. | .. | .. | N.—15,724 | .. | .. | .. | .. | .. |

as determined by numerous tests is not a very variable quantity, and suggested that a definite heat value should not be stated in the specification.

(4) Mr. Batho put forward a specification for tar oils at the Diesel Engine Users' Association meeting of February 23rd, 1916, in the course of remarks he then made, as follows:—

*Specific gravity*: Between 1·0 and 1·1.

*Viscosity*: Generally 2 deg. Engler (all coal tar oils are very fluid).

*Flash point*: 100 deg. Fah. to 130 deg. Fah.

*Colour*: Tar oils are, as a rule, dark to almost black. One drop on white paper should show no black residue, as is the case with tar. This black residue means a large percentage of free carbon or other tar ingredients.

*Lower calorific value*: Between 15,800 and 16,500 B.T.U.'s per lb.

*Ash*: Should not exceed 1 per cent (unburnt residue of tar oil is mostly harmless).

*Water*: Should not exceed 1 per cent.

*Sulphur*: ·5 to 1 per cent.

*Pitch*: If the tar oil contains a high percentage of residue which only begins to vaporise at 400 deg. Cen., then the same results can be expected as with tar; that is to say, one must anticipate a considerable amount of dirt in the engine and the exhaust valves will require frequent cleaning and grinding in.

The notes attached to the above enhance the value of the specification.

*(To be continued)*.

## THE CONDENSATION PUMP: AN IMPROVED FORM OF HIGH VACUUM PUMP.*

By Irving Langmuir.

Summary.—Two new types of condensation pump are described, one built wholly of glass and the other wholly of metal. In these pumps a blast of mercury vapour carries the gas into a condenser. The method by which the gas is brought into the mercury vapour blast in the condensation pump is based on a new principle, the gas to be exhausted being caught by the blast of vapour and forced by gas friction to travel along a cooled surface. The action of this pump depends primarily upon the fact that all the atoms of mercury striking a mercury-covered surface are condensed (no matter what the temperature). It is for this reason that the term "condensation pump" is proposed.

In a recent article in the *Physical Review*† the writer described a new form of mercury vapour vacuum pump, which was characterised by its extreme speed and the high degree of vacuum attainable.

This pump operated extremely satisfactorily, but was rather difficult to make. Trouble was frequently experienced by some liquid mercury collecting at the bottom of the annular space, and this interfered with the free passage of gas into the pump.

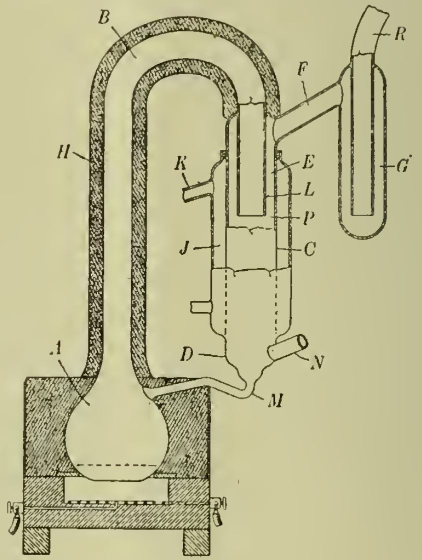
### The Improved Type of Glass Pump.

To completely avoid these difficulties the design shown in Fig. 1 was adopted. In this pump mercury vapour from the flask A is carried through the thermally insulated tube B to the nozzle L. The vessel to be exhausted is connected to R. The gas from this vessel passes through the trap G and the tube F into the annular space E. At P this gas comes into contact with the mercury vapour blast issuing from the nozzle L, and is thus forced outward and downward against the walls of the tube C, and is finally driven down into the space D from which it escapes into the rough pump connection N. The mercury which condenses on the sides of the water-cooled tube C passes back through the tube M into the boiler A.

By this construction none of the mercury which condenses passes into the annular space E, and thus the troublesome blast of mercury into the tube F is wholly avoided. The glass-blowing work on this type of pump is also much less difficult than on the earlier type.

In order that the pump may function properly it is essential that the end of the nozzle L (Fig. 1) shall be located below the level at which the water stands in the condenser J. The other dimensions of the pump are of relative unimportance. The distance between L and D must be sufficiently great so that no perceptible quantity of gas can diffuse back against the blast of mercury vapour, and so that a large enough condensing area is furnished.

The pump may be made in any suitable size. Some have been constructed in which the tube B and the nozzle L




The Condensation Pump.—Fig. 1.

were $1\frac{1}{4}$ in. in diameter, while in other pumps this tube was only $\frac{1}{4}$ in. in diameter, and the length of the whole pump was only about 4 in. The larger the pump the greater is the speed of exhaustion that may be obtained.

### Operating Characteristics.

In the operation of the pump the mercury boiler A is heated by either gas or electric heating, so that the mercury evaporates at a moderate rate. A thermometer placed in contact with the tube B, under the heat insulation, usually reads between 100 deg. Cen. and 120 deg. Cen., when the pump is operating satisfactorily. Under these conditions the mercury in the boiler A evaporates quietly from its surface. No bubbles are formed, so there is never any tendency to bumping.

Unlike Gaede's diffusing pump, there is nothing critical about the adjustment of the temperature. With an electrically-heated pump, in which the nozzle L was $\frac{3}{8}$ in. in diameter, the pump began to operate satisfactorily when the heating unit delivered 220 watts. The speed of exhaustion remains practically unchanged when the heating

* Abstract of an article in the *General Electric Review* (U.S.A.).

† Langmuir, *Physical Review*, VIII., 48 (1916).

current is increased even to a point where about 550 watts is applied.

The back pressure against which the pump will operate depends, however, upon the amount and velocity of the mercury vapour escaping from the nozzle. Thus, in the case above cited, with 220 watts, the pump would not operate with a back pressure exceeding about 50 bars,* whereas with 550 watts back pressures as high as 800 bars did not affect the operation of the pump.

### General Theoretical Considerations.

Vacuum pumps are characterised principally by three factors:—

1. *Back pressure* against which the pump may be operated. This is the pressure on the exhaust side of the pump, as for example, at X in Fig. 1.

2. *Speed of the Pump.*—Gaede has defined S the speed of a vacuum pump by the equation—

$$S = \frac{v}{t} \log \frac{p_2}{p},$$

where $t$ is the time required for the pump to reduce the pressure from $p^2$ to $p$ in a vessel having the capacity $v$. The speed is thus measured in cubic centimetres per second. In the case of a piston pump this is approximately equivalent to the piston displacement per second.

3. *Degree of Vacuum Attainable.*—This is the lower limit to the pressure which may be obtained in a closed vessel connected to the pump. For convenience we shall refer to the back pressure acting on the pump as the exhaust pressure, while the pressure at which the gas enters the pump we shall call the intake pressure.

Most mechanical pumps of the piston type are built to exhaust at atmospheric pressure. But mechanical rotary pumps are frequently designed to be used in series with "rough pumps," in which case they operate with an exhaust pressure of a few hundredths of a megabar (1/5 cm. of mercury). Newer forms of pumps such as Gaede's molecular pump and diffusion pump require still lower exhaust pressures (approximately 10—100 bars, roughly 0·01 mm. to 0·1 mm. of mercury). Such pumps are always used in series with good mechanical pumps.

The type of mercury vapour pump shown in Fig. 1 operates with exhaust pressures ranging from 50 to 800 bars, depending upon the amount of heat supplied to the boiler A.

With the exception of Gaede's molecular pump, which gives a maximum speed of about 1,300 cubic cm. per second, mechanical high vacuum pumps have not had speeds exceeding 100 or 200 cubic cm. per second. Gaede's rotary mercury pump, for instance, gives a speed of about 120 cubic cm. per second. In nearly all cases the speed of a pump is practically independent of the exhaust pressure against which it operates, unless this is raised above a certain rather critical value at which the pump ceases operating satisfactorily.

With most types of vacuum pump the degree of vacuum attainable depends to a large extent on the exhaust pressure used. This is usually due to leakage back through the pump. In the Gaede molecular pump, operating at low pressures, there is a strict proportionality (about 50,000 : 1) between the exhaust pressure and the lowest attainable intake pressure.

*(To be continued.)*

* The bar is the C.G.S. unit of pressure: 1 dyne per sq. cm. One bar is equal to a pressure of 0·00075 mm. of mercury, or about one-millionth of an atmosphere.

## FACTORIES: THE BUILDING AND ORGANISATION OF THEM.

By H. O. Blackford.

*(Concluded from page 251.)*

### Muddling Through Things.

We often hear during these times that, as a nation, we like to muddle through things. But we also have seen with our own eyes, and intelligence, how much our vital business needs lay in the hands of others, where we least thought them to be, who certainly are not muddlers. And, as far as I can see, to get the results so many people are crying for, there is a decided need to start at the bottom and put up some factories that will be able to compete with trade rivals, because output will be on a high enough scale and little waste entailed with it.

We are very conservative in our business ideas, especially those of a sweeping nature. They are simply smiled at, no effort being made even to see if they are right. Can you imagine an English firm turning out cars in American style? I mean in numbers. The undertaking would frighten them before they started on it, and small wonder, considering the ground they have to start on.

### Suitably-planned Works.

A works planned with due consideration given for expansion will have, providing the chassis is as practical as the works, an advantage which cannot be over-estimated in the fields of trade after the war. Those are bound to come in certain directions, such as cars for commercial use and on the land, and for Colonial markets. Aero engines, medium in price, power, and weight, cars for the owner-driver, and small low-speed heavy engines for coast fishing.

In a compact little island as we are, a factory ought to be able to run anywhere if it is only large enough to pay for its running.

### Too Keen in Design and Too Slow at Business.

All that I have said so far seems to indicate that I have but a small opinion of English firms, and that I hold up the Americans as an example to everyone. Well, not exactly so. To sum up, so far I firmly believe our design throughout is vastly superior to any in the world, but our methods of producing and floating the article need a thorough shaking up. We are too keen in design and too slow at business. The latter takes a second place, which, after this war, will mean sink or swim for the trade.

The second part of my paper relates to the staff; but before I get along with this I must say a few words about the apprentice.

### About Apprentices.

It seems the main object of most educational authorities is to mould and shape every boy alike, and if he has any natural gifts, to squash them. In other words, a boy who may be brilliant in one direction is often enough cramped and stifled till he has given up hope of trying. Perhaps, strictly speaking, some light has been let in, but it is small enough. A young man should specialise, but at present the market does not pay for it. And it should be for his teachers of knowledge to see, if they can, what bent the student has, and develop it for him. More scope will have to be given in the future to the scientific side of commercialism, and to those who have a gift in that particular direction should be given a more liberal chance to do themselves and their country good. As the future lies always in the hands of the rising generation, it is well to see they start at no disadvantage in the struggle.

### Education in the Works.

The same applies to the practical education of the apprentice in the works. It is rarely that supervision given to the boy is personal enough to see what special qualities he has. Usually, if he has any, and luck as well, then they come out. But that must, surely, be too doubtful a method for the future, and if an apprentice has a decided bent for the machine shop, then I say let him specialise on it. And I have little doubt, if all are carefully watched and placed, the future will be in good hands. For sooner or later some part of it is bound to fall on their shoulders. Men so trained would be in great demand when the tightening up of the trade commences.

Systems of properly training the apprentice have no doubt been started here and there, but are by no means general enough to make themselves felt as a national asset, which is wanted.

The stopping, as far as possible, of putting round pegs in square holes has yet to be properly attended to. Again, I say, this war has given us a few instances of that kind of business.

### Questions of Responsibility.

Responsibility does not start and finish with a head or heads of a firm. It is up to each individual to do his, and his duty alone, to make a complete success of the work in hand. And if he is not in his proper sphere, then it is not even fair to expect good results. All the cleverest men in the world would be of little use if their orders and directions were not carried out by those under them exactly to orders, with the least delay and unnecessary fuss as possible. All this I say to emphasise the fact that an apprentice should be given every opportunity of coming into contact with the latest methods of manufacture, so that he may be able to start where others left off, and make the vitally necessary improvements of detail, which will keep an advance of getting the work out ever moving.

That the apprentice may do this without upsetting the department requires some solving in itself. These last 10 years have seen improvements of a sort, but they seem without a fixed course, and as the road is now leading a boy is often enough put into a shop and given a repetition job, which, if he fills well, he is kept at until the time comes round for his removal to the next shop. Here again the need for a personal and independent supervision is clearly apparent.

Why have these subjects not been gone into by an authoritywho has the power to act? I believe it is because the need has not been considered a pressing one for such action. But surely a better time than the present could not be found for putting our resources on a proper footing and organising even the apprentice.

### The Main Staff.

After those few words on the apprentice, we now turn to the main staff. I expect most of you will agree with me in saying that no two firms work on the same basis regarding their staff, but I think many firms running to-day have a fault common to all. It is this: to leave the control of a factory in the hands of either one or two men, who are usually engineers. Assuming the factory has been built for an output, the tremendous detail of the whole place should be divided up something like I am about to suggest. The extensive detail of organising in itself does not appeal to an engineer at all, and if it does, usually it is out of his sphere. I will not go so far as to say all engineers are bad organisers; far from it, but it is plain they cannot be really clever at half a dozen jobs at once, and it is not justice to expect one man to be responsible for the whole works. Yet there are many factories who absolutely rely on one or two to make the whole business a success. Granted they do it, but the output and price of the finished article can testify who suffers, and it is impossible for a factory so run to expand as it should.

### An Active Board.

There should be an active board, who would meet weekly and check the whole concern in a mild way. I do not mean a directors' board, whose main concern is money, no matter how it is obtained, but a council of, say, six members, under a director, as chairman. It should be their duty to each bring up before the council what has passed under his notice, and see what has to be done in the matter. In a few minutes I will detail those six out, but to continue: The most difficult part would be to get those six working as one. The human element would appear at times very strong, and naturally hard to keep in check.

To mention the chassis had a weak point would no doubt upset the designer, who usually regards the man who uses the car at fault, and not the design. It seems the practice to quietly cover and screen up faults in design, very obvious ones at times, too. Surely that is a very blind way of going on, and that to arrive at and check complaints, if they are genuine, shou'd be the business of any firm working for a larger market. In the end it only recoils on the firm who will not move. People want value for money, and will do so more and more when the war is over. The six and their duties (perhaps more or less to suit the factory concerned) are:—

### The Works Manager.

He would be an engineer of sound training. Under him should be all shop foremen. They would be required to meet one definite evening a week under the works manager to discuss what was ahead for the next week, or longer, how the output stood, extensions wanted, how the shops stand regarding labour, and improvements of a large nature to be gone into, and much other detail. Each foreman would bring a signed report of how he stands regarding material in and out. That is to say, the machine-shop would be split up, the foreman coming under this heading.

### The Head Designer.

He should be assisted by an experimental shop, with a picked all-round man at the head. They would work very close together—the assistance the experimental shop should give the drawing-office, I mean. The duties would be the designing and careful testing of new chassis, the collecting of all data relating to the individual car, and outside information of any use as well. Looking into carefully of faults reported from the repair and claims department, seeing they are rectified with as little delay as possible. The testing and reporting on of new ideas and inventions, and their adaptation to the chassis, not waiting for another firm to take the lead. This department should be equipped with the latest scientific instruments, as far as practically wanted.

### The Organiser.

Under the above should be all clerks, office systems, piece-work systems, and general office checkings of all descriptions. The controlling of the stores, both rough and finished, and, with the works manager, should be held responsible for extensions made.

### Repair Shop and Claims Manager.

Under this manager should be all outside workers for the firm, and the manager should keep a watchful eye on any

recurring fault in the chassis before his notice. If it is a small one report to the Head Designer; if too large to be dealt with there, then bring it before the Board. It may mean a very large item on the production bill to be rectified at once. This department should be one of the most useful ones in the works for putting in order any faults which show themselves in the chassis, after some thousands of miles have been run. Not nearly enough attention is paid by the Departmental Organiser to the repair department. I believe it is below their dignity usually.

### The Head Salesman.

In addition to controlling the sales, he should have the leading voice on what the public want in the shape of the new chassis, horse-power, weight, general outline, and price. As he is on the pulse of the public, his decisions should be carefully weighed and looked into before putting aside.

### The Buyer.

He should be responsible for the quality and quantity of all material bought for the works. In the case of new machinery or special plant he would be advised by the Works Manager.

The above are, briefly, what the main duties of those six should be. No doubt, the whole number would not meet every week, but as many as convenient ought to turn up. I believe such a scheme, or one similar, would soon rectify and check faults, both in the works and chassis, and would cut out useless work right and left. The trouble would be to get them to co-operate properly, and I believe time would do that.

Each department should stand by itself and obtain its own necessary output. At present, for reasons purely and simply lack of organisation and co-operation, you find one department waiting on the other. One on short time, and others all hours they can put in. Because having no organised system, it is a case of—well, do your best to get it out, and next time we will do it differently; we shall be able to handle it better, etc. That goes on time and again.

Regarding a large number of works staffs, which I hope you will pardon my putting so bluntly, it will be found to have changed nearly all over the factory in each department every few years, for only one apparent reason, and that is a pleasant exchange of places. By this I do not mean to say do not move a man if he is better in one department than another, but, as far as I can see, it is not always ability. A department foreman is one who is up to his job, and it is worth his while to specialise on it, and in the course of time he obtains practical experience, whose value cannot be over-estimated. But if a man knows his place is one simply to fill, and do what he is told only, then small blame can be placed on his shoulders.

In conclusion, I must say there has been in the past but scant attention paid to output on a large scale in this country, and not near the encouragement given to those who can do it. But the time, I firmly believe, is at hand to look the matter full in the face, and in a broad-minded way, with no personal axes to grind. We shall have a chance, when this war is over, of turning over a new leaf, which is given to few. How other nations and how we shall pull through rests with each individually. We have one lesson of unpreparedness before us, and it must not be repeated.

*(Concluded.)*

## WORM GEAR AND WORM GEAR MOUNTING.*

By F. W. Lanchester, M.Inst.C.E. (Member of Council).

### Introduction.

In a paper read before this Institution in 1913,‡ the author dealt with the subject of worm gearing broadly, and more particularly with the Lanchester Worm Gear, which was the first to be successfully introduced in automobile practice. It is, perhaps, unnecessary here to recapitulate the distinctive features of worm gear of different types. It is enough to say that at the present time there are, broadly speaking, two types of worm gear in competitive employment—the Lanchester gear, which may be spoken of as a variant of the Hindley worm, and the cylindric parallel, or straight worm such as that marketed by Messrs. David Brown and Co., Messrs Wrigley, and others, which may be taken as a development of the ordinary worm gear in common use by engineers for a century or more. Although on the one hand the Lanchester gear is described as a form of Hindley, and the parallel or cylindric worm as that of ancient practice, such descriptions do not entirely do justice to either the one or the other. Worm gear for power transmission (where mechanical efficiency is the talisman of success) is a comparatively modern development, and the gears used to-day in motor-car transmission and in other cases of power transmission, such as electric lifts, hoists, etc., bear but a very faint resemblance to their forerunner, which was designed and used for motion transmission alone. Indeed, it is correct to say that, in the more ancient applications of worm gear, a common condition was that the drive should be irreversible; in truth, it was when such drive was wanted, as in a hand winch, that the engineer turned his thoughts to the worm wheel as a solution. It is a point of importance that, so long as this irreversibility is a condition, the mechanical efficiency as a power transmitter cannot exceed 50 per cent. We may therefore take it that although it may be difficult to draw a hard and fast line between the worm gear of old and the worm gear of to-day, there is, from the practical point of view, as complete a break of continuity as if such a hard and fast line existed.

Thus, in the case of motion transmission† it was uncommon for worm gear to have an efficiency higher than 30 per cent or 40 per cent; but immediately the problem is changed to that of economic power transmission and the engineer concentrates his attention on the question of mechanical efficiency, a duty as high as 94 per cent or 95 per cent, or, as shown in the previous paper, even 97 per cent, is to be obtained.

In the previous paper the question of efficiency was made the pivot point of the discussion, and the results of the tests made by the staff of the National Physical Laboratory at the Daimler Works were freely used in the body of the paper, the particulars of the tests (with the N. P. L. report) being given as an Appendix (Appendix I.). Incidentally, in that paper particulars were given of the author's dynamometer by which the said tests were made, and by which a far higher degree of accuracy was obtained than has ever been previously certified. In that paper also was discussed the theory of worm gear efficiency by the

* Paper read before the Institution of Automobile Engineers.

‡ See Proc., I.A.E., Vol. VII., p. 215.

† The distinction between motion transmission and power transmission is arbitrary, since in every case a transmission of power takes place, even though in small degree. It is the object in view which is the distinctive circumstance, and whether or no mechanical efficiency is a point of importance.

author's methods. Much of the matter was criticised severely in the discussion by Mr. F. J. Bostock, who not only challenged the theoretical work but also the comparative test results as between the parallel and Lanchester types of worm. Mr. Bostock based his criticism on the practical side of his experience in association with Messrs. David Brown and Sons, as the makers of power transmission worm gear of the parallel type, in a written communication to the paper. Mr. Kerr-Thomas also contributed a written communication, in which he expressed disagreement with some of the author's conclusions. These contributions were dealt with in detail by the author in his reply, but they appear to indicate considerable misapprehension as to some of the fundamental facts connected with worm transmission design, and to some degree the present paper may be taken as directed to clearing up these points of controversy more definitely than was attempted in the earlier paper, and to demonstrate in an irrefutable manner some of the essential differences which result in the practical application of the two systems of gear cutting.

In the previous paper the maker of the particular parallel gear which was tested in comparison with the Lanchester was not stated: it might have been considered unfair to have named the gear when the maker would have no chance to ascertain or satisfy himself that the best possible had been done with it. In the present paper the maker of the gear of parallel type which has been used as a comparison is definitely given; it is the gear of Messrs. David Brown and Sons, obtained direct from one of their customers. It is presumably a fair sample of the gears supplied by that firm. It is, of course, much more satisfactory to be able to state the maker of the gear which has been subjected to investigation, and the writer therefore has had no hesitation in taking up the gauntlet thrown down by Mr. Bostock.

The present paper naturally divides itself into two parts; the first part relates to a detail discussion of the theoretical side of the subject, and may be taken as supplementary to the discussion of the previous paper, the second part relates to a practical examination of the "solid geometry" of worm gear by a new method, and is in fact a detail comparison of the Hindley and parallel types of worm gear as exemplified in the Lanchester and David Brown respectively.

A third section of the paper is devoted to the question of worm gear mounting or housing, a feature in which the practice in respect of the two types does in certain respects present differences.

*(To be continued.)*

The Telephone in Railway Work.—The telephone is (according to the *Railway News*) to be used instead of the telegraph for despatching trains on the whole of the Southern Railway system between Washington and Atlanta, 649 miles. Between Washington and Spencer (N.C.) the telephone is now in use, and authority has just been given for the construction of two copper telephone circuits between Spencer and Atlanta (314 miles). When this work is completed the Southern will have continuous train despatching and message circuits between Washington and Atlanta, and these two circuits will also provide a third or phantom circuit for talking purposes, and a simplex telegraph circuit between the offices at Washington, Atlanta, Charlotte, and important division and junction points, such as Monroe, Va., Greensboro, N.C., Spencer, N.C., Hayne, S.C., and Greenville, S.C. The telephone has several advantages over the telegraph. Service is quicker and it is easier to guard against errors. The despatcher writes the order as he sends it, spelling out all figures such as train numbers, engine numbers, and time. The receiver writes the message as he receives it, and then repeats it to the despatcher, spelling out all figures. The telephone brings the sender and receiver into close touch, and the despatcher, should occasion arise, can talk personally to the conductor or engineer of any train on his division.

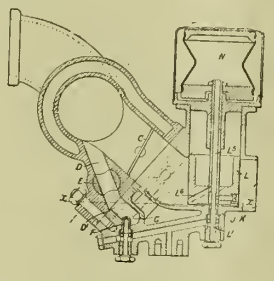
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

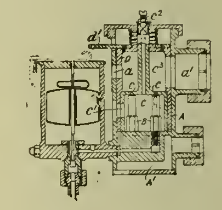
## ABSTRACTS OF SPECIFICATIONS.

### INTERNAL-COMBUSTION ENGINES.

105,102.—Napier & Son and A. J. Rowledge, 211, Acton Vale, London.—March 29th, 1916.—A main carburettor has combined with it, in order to vary the richness of the mixture, a supplementary carburettor, both being controlled by throttle valves which are independently actuated. The main carburettor may be of any type, that described comprising a nozzle J controlled by a needle valve L1 carried by a piston L, which controls the air passage K. The piston is actuated by suction transmitted through passages L6, L5 to the bellows N. This carburettor is controlled by a throttle valve C. The supplementary carburettor comprises an uncontrolled nozzle F placed at the junction of two gauze-covered air-inlet passages G, the mixture-outlet passage D being controlled by an independently-actuated throttle valve E. The nozzle F is disposed below the fuel level $x-x$, so as to become flooded when the valve E is closed, the pool of liquid thus formed facilitating starting, and providing a reserve of rich mixture when the throttle E is opened. In a modified construction, the nozzle F projects slightly into the choke-tube D1, which is horizontal, thus providing a chamber in which fuel may collect. The nozzle F may be so arranged that fuel does not collect unless the float or other device is manipulated to raise the fuel level temporarily.



Patent 105,102.



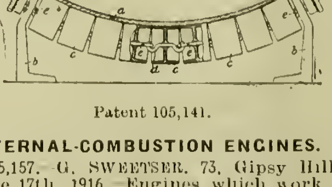
Patent 105,130.

### INTERNAL-COMBUSTION ENGINES.

105,130.—L. Burn, Waterworks, Uppingham, W. A. Gall, Brunswick Road, Withington, Manchester, and O. Axon, Glebelands Road, Ashton-on-Mersey, Cheshire.—April 12th, 1916.—Three nozzles B are supplied respectively with light fuel such as petrol or benzol, heavy fuel such as paraffin, and water from three separate float chambers, and are enclosed by a chamber C which has a perforation c over each nozzle, an air port c1, and a tubular shank c3 with an air-adjusting screw c2. An air-regulating sleeve D provided with a lever d1 controls the air port c1 and air ports a, from which air passes over the perforations c to the induction pipe a1. The fuel is heated by exhaust gases passing through a chamber A1 in the bottom of the body A; or a heater may be interposed in the paraffin and water supply pipes or in the induction pipe. The float chambers are supplied from separate tanks through pipes provided with separate valves, or with valves so arranged that, when the light fuel supply is on, the paraffin and water are cut off, and *vice versa*.

### CONVEYORS.

105,141.—Fraser & Chalmers, 3, London Wall Buildings, London, and F. G. Mitchell, Penthorpe, Bexley Road, Erith, Kent.—May 13th, 1916.—The rollers c are carried and connected together by a flexible chain connexion which allows the set to assume a suspension curvature or the shape required for the belt a and also to rotate. Each roller c is secured on a rod or link d, e having a hook or an eye, and the end links are supported in ball bearings g, the chain being suspended between brackets b. The end links may be fixed, and the rollers may be free to revolve on the links of the chain.



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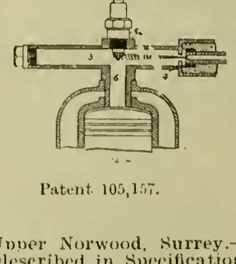


Patent 105,157.

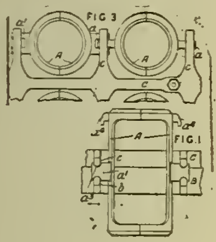
### INTERNAL-COMBUSTION ENGINES.

105,157. G. Sweetser, 73, Gipsy Hill, Upper Norwood, Surrey.—June 17th, 1916. Engines which work as described in Specification 23,574/13, by injecting a heavy oil on to an igniter at starting

and afterwards injecting the oil during the suction stroke, are constructed with a combustion chamber 3 separated from the cylinder by a passage 6 and containing the igniter 5 and injector 4.

### CLEANING TUBES.

105,171.—A. E. THOMPSON and F. RATCLIFFE, Ettingshall Boiler Works, Wolverhampton.—July 18th, 1916.—In a tube-scraping apparatus for use with fuel-economisers, the two or more scrapers A, Fig. 1 in each set are supported between the lifting-bar B and guard C of the carrier by forming the scrapers with one or more lugs $a1$ having notches $a3$, which are engaged by arms $b$, $c$ on the lifting-bar and guard respectively. Fig. 3 shows an arrangement in which pairs of scrapers with semicircular edges are employed, some of the scrapers having a single lug $a$, and others having two lugs $a1$. The scrapers may also be provided at their upper ends with a hook-shaped projection $a4$ adapted to engage a bar or other implement so as to facilitate removal or insertion of the scrapers. Specification 105,172 is referred to.



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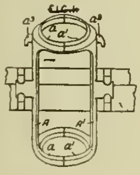


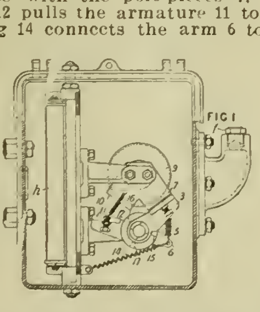
Patent 105,172.

### CLEANING TUBES.

105,172.—A. E. THOMPSON and F. RATCLIFFE, Ettingshall Boiler Works, Wolverhampton.—July 18th, 1916.—In a tube-scraping apparatus for use with fuel-economisers, the ends $a$, $a1$ of the two or more scrapers A, A1 form a continuous scraping edge which lies in a plane not at right-angles to the axes of the tubes being cleaned. The scrapers are supported in the manner described in Specification 105,171, and may also be provided at their upper ends with a hook-shaped projection $a3$ adapted to engage a bar or other implement so as to facilitate removal or insertion of the scrapers.

### ELECTRIC MOTOR CONTROLLERS.

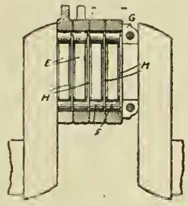
105,181.—F. NEWTON and NEWTON BROS., Market Place, Derby.—Aug. 2nd, 1916.—The first operation of a controller closes the motor circuit and also stores energy in a spring for the further actuation of the controller, which is held fast until the motor current drops to a predetermined value. The electro-magnet used to hold the controller in its first position also constitutes the automatic release magnet. The controller is enclosed in a water-tight casing, and the leads are taken in through the gland $f$. The starting resistance is wound on enamelled iron supports $h$. The controller fingers are operated by a spindle, upon which is loosely carried an armature 3 connected to the handle by a lost-motion connexion to render quick break possible, and connected by a spring 5 to an arm 6 fixed on the spindle. A second armature 11 is loosely mounted on the spindle, and the armatures 3, 11 co-operate with the pole-pieces 7, 10 of the electro-magnet 9. A spring 12 pulls the armature 11 towards the electro-magnet, and a spring 14 connects the arm 6 to the casing. The



disc of the arm 6 has a stop 15 to engage the armature 3 and stops 16 17 to engage the armature 11. In the off position, the armature 3 and arm 6 are pulled by the spring 14 away from the electro-magnet 9, and the armature 11 is pulled by the spring 12 to the pole-piece 10. When the spindle is rotated in an anti-clockwise direction the motor circuit is closed through resistance, and the armature 3 is moved mechanically to the pole-piece 7 and is held there by the electro-magnet 9, which carries the motor current and also holds the armature 11. During this movement, the spring 14 is stretched until the stop 16 engages the armature 11, and after this engagement the spring 5 is stretched. As the starting-current decreases, the armature 11 is released, and the spring 5 acting through the stop 16 snaps off the armature 11 and moves the arm 6 to throw the controller into its second position, thus cutting out resistance. When the electro-magnet 9 is de-energised, the spring 14 moves the arm 6 and armature 3 to the off position, and the spring 12 returns the armature 11 to the pole-piece 10. The spindle may be operated by an electro-magnet for remote control, and an armature may be provided to shunt the flux in the armature 3 and so act as an overload release. The number of controller steps may be increased by providing additional sets of mechanism, the parts being interlocked to ensure a correct sequence of steps.

### BEARINGS.

105,216.—G. E. BRADSHAW, A.B.C. Motor Works, Hersham, Walton-on-Thames, Surrey.—Jan. 25th 1917.—In a roller bearing for connecting-rod ends of petrol engines as described in Specification 104,483, the discs H which separate the rows of rollers F are turned integrally with the crank pin or shaft E. If one row only is used, the disc separates the rollers from the divided collar G at the end of the bearing.



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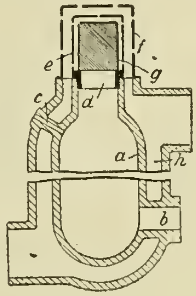


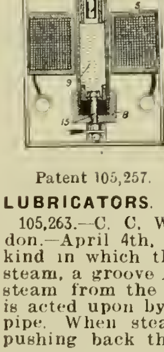
Patent 105,253.

### INTERNAL-COMBUSTION ENGINES.

105,253.—W. MORGAN, 38, Wellington Road and W. MILLS, Bridge Street West, both in Birmingham.—March 31st, 1916.—Exhaust or other inert gas is admitted at substantially atmospheric pressure to a vaporiser to serve as a carrying-medium for the fuel. The vaporiser $a$ is surrounded by an exhaust jacket $h$, and is provided with an inlet $c$ for fuel or rich mixture, and an outlet $b$ to the engine. A portion of the exhaust gases in the jacket $h$ passes to a casing $f$, whence it enters the vapouriser through a perforated casing $e$, filter $g$, and aperture $d$. Perforations in the casing $f$ maintain the gas therein at atmospheric pressure. In a modification, the exhaust or other inert gas is admitted to the vaporiser, from a chamber in which it is circulated at substantially atmospheric pressure, through a conduit in which a constriction is provided, a fuel nozzle being placed at the constriction. Specification 106,074 is referred to.

### ELECTRIC SWITCHES.

105,257.—A. P. TURNBULL, "Stock," Wandella Avenue, Roseville, New South Wales, Australia.—April 1st, 1916.—An electromagnetically-operated switch comprises a vertically-disposed insulating tube 4 closed at its ends by metallic caps 7, 8, which constitute the main terminals of the switch. The tube contains mercury 9, which is in connexion through the bolt 15 with the lower terminal, and a soft-iron tube 10 floats upon the mercury. An adjustable contact rod 12 depends into the tube, as shown, and is loosely surrounded by a sleeve 11 of insulating non-combustible material, for example soapstone, which also floats upon the mercury. The tube 4 is surrounded by a solenoid 5 with a single winding or with differential windings, which, when energised, draws the iron tube into the mercury, the level of which rises, lifting the soapstone sleeve until, finally, the mercury contacts with the rod 12 and the circuit is completed. When the solenoid is de-energised, the iron tube rises and the surface of the mercury falls, the soapstone sleeve falling over the point of the contact rod 12 and extinguishing the arc as the mercury leaves the contact rod. The device may be mounted on gimbals.



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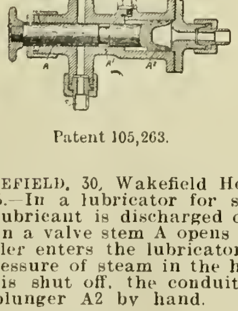
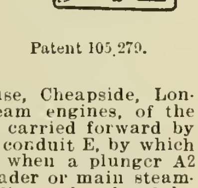


Patent 105,263.



Patent 105,279.

### LUBRICATORS.

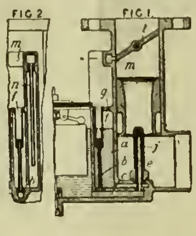
105,263.—C. C. WAKEFIELD, 30, Wakefield House, Cheapside, London.—April 4th, 1916.—In a lubricator for steam engines, of the kind in which the lubricant is discharged or carried forward by steam, a groove A1 in a valve stem A opens a conduit E, by which steam from the boiler enters the lubricator, when a plunger A2 is acted upon by pressure of steam in the header or main steam-pipe. When steam is shut off, the conduit E can be closed by pushing back the plunger A2 by hand.

### BELT AND BAND FASTENINGS.

105,279.—T. A. SMITH, Charles Street Works, and J. BANT, 43, Lumley Road, both in Walsall, Staffordshire.—May 31st, 1916.—In a fastener for driving-belts and other bands or straps, comprising a plate $a$ formed with reversely-directed keyhole slots $g$ to receive studs $i$ passed through punched holes in the belt ends, the heads of the studs rest on inclined surfaces $h$ formed on the plate, so that the fastening is tightened by a pull on the belt. The plate consists either of two pieces hinged together, or is in one piece as shown in Fig. 4. In the case of a plate having two or more slots side by side, the corresponding studs may be carried rigidly on a single base-plate.

### INTERNAL-COMBUSTION ENGINES.

105,309.—J. FAGARD, 147, Corporation Street, Birmingham.—Nov. 4th, 1916.—In carburettors wherein an auxiliary "pick-up" nozzle is situated in the choke-tube and is fed from a well open to the atmosphere, the well is supplied from the float chamber through an upstanding tube, the flow of fuel through which is automatically arrested as the suction increases and the main nozzle is brought into action. The main nozzle e is fed from the float chamber through the passage c and is surrounded by the auxiliary nozzle




j fed from the bottom of the well a open to the atmosphere through a passage g and tube f and supplied from the float chamber through the upstanding tube b. A pilot nozzle m is also supplied from the well a through a tube n. As the throttle t is opened, the flow of fuel through the nozzle j lowers the level in the well a, the air is ultimately drawn through the tube f, which has the effect of arresting the flow of fuel through the tube b. In a modification, the tubes b, f are formed as a single tube with an orifice corresponding to the lower end of the tube f. In a further modification, the auxiliary nozzle enters the choke-tube at right-angles thereto. A restriction may be placed in the tube b, or in the passage c between the float chamber and the tube b

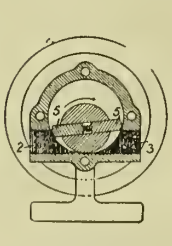
### DRIVING CHAINS.

105,320.—H. S. YOXALL, G. WADHAMS, and A. T. BEST, Oliver Street Works, Birmingham.—Jan. 18th, 1917.—In chains of the kind described in Specification 9,162/14, wherein compression springs 12 are inserted between abutment plates 13 fixed between projections

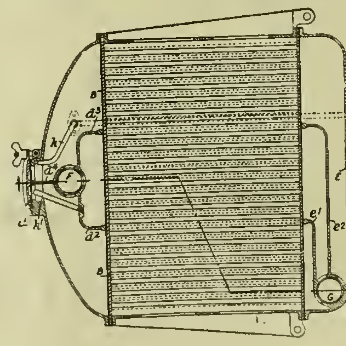

on certain links to cause the chain to assume a zigzag form when slack, the apertures in the plates 13 which receive the guide-rods 11 of the springs provide bearing-surfaces longer than the thickness of the plates, as shown in Fig. 4, and permit the plates to rock angularly in one direction on the guide-rods 11, but prevent lateral movement thereon.

### ROTARY PUMPS.

105,350.—C. C. PERKS, 148, South Road, Erdington, Birmingham.—Aug. 14th, 1916.—Detrimental trapping of liquid in a rotary pump having a pair of spring-pressed vanes 5 arranged as shown in Fig. 4 is prevented by disposing the inlet and outlet ports 2, 3 tangentially to the circular casing at the point of contact of the rotor. Specifications 6,746/89 and 18,329/93 are referred to.



Patent 105,350



Patent 105,351.

### RADIATORS FOR INTERNAL-COMBUSTION ENGINES.

105,351.—H. B. WATSON and T. C. BILLETOP, High Bridge Works, Newcastle-on-Tyne.—Feb. 28th, 1916.—In radiators for internal-combustion engines, the inlet and outlet chambers are divided by partitions which extend between multiple-way inlet and outlet valves so arranged that one or more sections of the radiator can be isolated, the cooling-fluid circulating only in the remaining sections. In the construction shown in Fig. 1, the radiator is divided into three sections by partitions d2, d3, d4, which are carried by the upper tube-plate B and radiate from the divided wall of an inlet plug cock F. Partitions e1, e2 co-operate with the casing E to form corresponding outlet sections, and they are connected directly to the valve casing, the outlet valve G being divided to correspond with the inlet valve F. Overflow pipes k, k1 are provided for the sections, connexion between them being afforded by a space between the partition d4 and the cover d1. Operation of the valves may be effected separately by hand or by gearing.

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THE

# Industrial Engineer.

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# EDITORIAL.

## THE THREATENED RAILWAY STRIKE.

As we are preparing for press the country is threatened with a strike of a certain section of railway employees, viz., the engineers and firemen belonging to the Associated Society of Locomotive Engineers and Firemen. This society demands that the railway companies should concede the principle of an eight-hour day. One stands aghast at the very mention of such a proposition at the present time when almost every industry except those in which raw materials are difficult to get is working all the hours it is possible to put in, with the object of increasing the supply of all those things which are necessary to carry on the war. We should be the last to quarrel with the demand for an eight-hour day in any trade. It has proved eminently successful in more than one engineering establishment, and we know of a case where those who control such an establishment are decidedly of the opinion that the system ought to be extended immediately after peace is declared. Notwithstanding this, the demand of a section of railwaymen is inconsiderate to the last degree, even if we recognise, as we do, that some of the men are working long hours now. It seems to us most difficult to understand the character of the men who prompt such actions at a time like the present. To our mind many of the sectional leaders must be utterly obsessed with their ideas. We could understand better a strike for increased pay, since for this there would be some semblance at least of justificaction on account of the still ever-rising food prices. Perhaps it will be said that increased pay will not compensate for the bodily weariness due to long hours of labour in a class of work which is trying to the nerves. We should certainly agree with the reply. But do not the same conditions obtain in munition works? Certainly they do, and herein there is little chance of obtaining the fresh air which falls so plentifully to the lot of a locomotive engineer and fireman, and which acts as a replenisher of energy to the body, even in the very best and most modern of workshops. In our view the demand will not withstand a moment's serious consideration. The men, in our view, will be well advised not to spoil their splendid record of war service by insisting upon a demand of so unreasonable and impossible a character.

We feel sure the general public would back up the men's demand were the time opportune, for it is fairly well recognised that the responsibility and nature of the work demands that for the safety of those who are entrusted to their care no undue nervous strain should be allowed to exist which might lead to disaster. We entirely agree with Sir Albert Stanley, the President of the Board of Trade, when he says that the Government could not during the war consider the principle of an eight-hour day, as this was not a condition arising out of war conditions; nor could an eight-hour system possibly be worked during the war, and this was freely admitted by the men's representatives. The present system

of railway control by the Government would continue for some time after the war, and there would then be an opportunity of raising and dealing with the question of hours. He could not believe that any responsible organisation of railwaymen, who had hitherto played such a splendid part in assisting the nation in its emergency, would jeopardise the prosecution of the war by authorising or taking part in a stoppage at this critical time. But he intimated, on behalf of the Government, that the necessary steps were being taken to deal with any emergency that might arise.

## Trade Items, Notes, &c.

Diesel Engine Users' Association.—A pamphlet has been published by this Association containing a full account of the discussion on Mr. Geoffrey Porter's interesting paper on "Tar Oil Fuel and Diesel Engines," read at a meeting of the Association last month, in which Messrs. G. W. F. Horner, F. W. Strickland, J. M. Ferguson, H. S. Russell, G. Nevill Huntly, E. A. Evans, P. H. Smith, C. T. Westlake, George B. Vickers, W. A. Turnbull, Napier Prentice and Percy Still took part, many of the observations having been communicated. Mr. Geoffrey Porter's reply is included.

Control of Iron Ore Mines.—The Minister of Munitions has issued an Order under which he takes possession of all iron ore mines in the counties of Cumberland and Lancaster. The Order takes effect from July 24th, all mines and quarries to which the regulation applies passing into the possession of the Minister of Munitions. The owner, agent, and manager of every such mine or quarry, and every officer thereof, and, where the owner of the mine is a company, every director of the company must comply with the directions of the Minister of Munitions as to the management and use of the mine or quarry, and if he fails to do so will be guilty of a summary offence against the Defence of the Realm Regulations.

Output of Copper in Japan.—The output of copper ore in Japan in 1916 amounted to 111,562 tons, as compared with 83,017 tons in 1915, and 78,700 tons in 1914, while exports amounted to 57,402 tons in 1916, as against 56,528 tons in 1915, and 43,305 tons in 1914. Russia now buys most of Japan's copper ore, her purchases amounting to 60 per cent of the total exports. The United Kingdom takes 20 per cent, while France, the United States, and India share the balance, but their dealings are not large. The consumption of copper ore in Japan has increased considerably during the last three years, the consumption in 1916 amounting to 59,690 tons, as compared with 27,723 tons in 1915 and 32,045 tons in 1914.

Tests to Determine Properties of Alloys.—We read in *The Electric Railway Journal* that the engineering experiment station of the University of Illinois has just completed another series of experiments to determine the magnetic and allied properties of alloys of iron and other metals. In 1915 experiments with iron-silicon alloys disclosed some remarkable properties which make those alloys superior to any other material for use in certain electro-magnetic machinery. These experiments were followed by others dealing with iron-aluminium alloys melted in vacuo, which have shown that aluminium, like silicon, greatly improves the magnetic properties of the metal, and also that aluminium imparts to the metal a greater toughness than silicon.

Making Phosphor Bronze.—In the making of phosphor bronze it is usually the better plan to use plain copper and tin plus the required amount of either phosphor copper or phosphor tin of known content necessary to add the percentage of phosphorus required. At the same time it is fairly easy to make this alloy by the direct use of phosphorus if this is added to the copper and well mixed before the tin is put in. When large percentages of phosphorus is added to a copper-tin alloy there is always risk, in some cases, indeed, the phosphor bronze being much weaker than the plain alloy of copper and tin. As a rule, a lot of the phosphorus is lost if castings are judged by analysis, but having done its work in the making of the bronze it is really not further needed in the metal.

Hydro-electric Power in New Zealand.—The question of developing hydro-electric power in the North Island, New Zealand, is being investigated by Mr. Evan Parry, who has issued an interim report on the subject. The best source of power, he considers, is in the Arapuni Gorge, eight miles from Hira, Hira where it would be possible to obtain 120,000 H.P. on a 50 per cent load-factor basis. He believes this scheme would be successful if only 40,000 H.P. were developed in the first instance; the cost of such a plant, with transmissions for serving surrounding districts, would amount to £1,200,000. The most suitable source of supply for Wellington is the Mangahao River, where 25,000 H.P. can be obtained on a 50 per cent load-factor basis; and later on a further source of power might be obtained in the Taranaki district to supplement this.

Ash in Coal Slacks.—When buying coal its content in combustible matters must be carefully examined in regard to prices paid for one thing, and to subsequent costs as another, because it costs as much to handle and carry dirt as it does coal, while a dirty coal costs considerably more than many people imagine owing to the necessity of removing the ashes and clinker produced. It does not matter what becomes of the heat generated, because in any case much of this is wasted; but much slack if purchased at the pit f.o.t. would be dearer at 6d. per ton than would be clean washed peas at 3s. 6d. or 4s. on the same terms In one analysis before us, unwashed slack gave free water 5·24 per cent; ash, 22·41 per cent; and sulphur, 1·69 per cent; while washed "pearls" of $^1/_{166}$ in. to $\frac{3}{8}$ in. sizes, when air dried, gave free water as 4·92 per cent; ash, 4·48 per cent; and sulphur, 1·11 per cent, this effecting a saving of 19·19 per cent, or, say, 3 cwt. 94 lbs. on each ton of coal purchased and practically stopping all charges for ash disposal, as less than 1 cwt. of waste per ton of coal should be produced at the furnaces.

Fire Tests of Ferro-concrete.—Having conducted fire tests of ferro-concrete in 1910, the Materialprüfungsamt, of Gross Lichterfelde, near Berlin, undertook new tests in 1914-15, on which Professor M. Garg has recently reported in the publication of the "Deutsche Ausschuss für Eisenbeton." Two houses were erected, 4 m. by 4 m., 8m. high, the chief materials being ferro-concrete prepared either with crushed granite or with crushed basalt. The particular points investigated were: Resistance of the concrete to internal fires, heat transference through the concrete, strength of the ferro-concrete structure before and after the fire, and behaviour of the structure during demolition. The report is not available, but from the *Schweizerische Bauzeitung* of May 19th we see that the houses stood the repeated, severe tests surprisingly well, better even than experts expected. The stairways of ferro-concrete and also of artificial stones proved excellent, and the mechanical properties of the iron were hardly impaired, although the temperature of the iron rose to 350 deg. Cen. The one unsatisfactory and, so far, unexplained feature was that fairly big pieces of hot granite-concrete sometimes flew off with almost explosive energy. This point is to be further investigated in the experiments, which have already been resumed.

## THE PROBLEM OF AEROPLANE ENGINE DESIGN.*

By Charles E. Lucke.

The problem of the aeroplane engine appeals strongly to every engineer because it is a problem of the lightest power plant. The lightest weight of engine proper per horse-power is to be secured first by obtaining maximum mean effective pressure at maximum speed; in other words, the product of the mean effective pressure and the speed must be a maximum. At the same time the weight of metal per cylinder, or per cubic inch of cylinder displacement per working stroke, must be a minimum—and with both of these factors the engine must be reliable in operation. So far, this reliability factor has been weakest, though lightness has been secured in engines good for short periods of running.

Not only must the metal weight of engine per horse-power be a minimum, but in addition the fuel weight to be carried must also be a minimum, because, as can readily be seen, the fuel weight necessary for flights of any length predominates over the engine weight. For example: taking a half-pound of fuel and oil per hour per horse-power as a fair value, it is readily seen how quickly that will catch up on engine weight when the latter is 4 lb. or 5 lb. per horse-power.

In undertaking an analysis of the aeroplane-engine problem from the records, the only conclusion that can be drawn is along the line of type. Data are almost entirely lacking. On the question of general engine types, attention might be called to a few points:—

The air-cooled motor has entirely failed in comparison with the water-cooled motor: the reasons are perfectly sound and secure. The 2-cycle engine has given way to the 4-cycle type.

Fixed cylinders have prevailed over rotating cylinders. Odd cylinder arrangements of queer, freaky forms have all been relegated to the scrap heap in favour of a few modern arrangements. The standard cylinder arrangements of to-day, which are the survivors of what may be called the inventive period, or at least the first inventive period, are the six and eight cylinders in line, and the eight, twelve, and sixteen V's.

It really appears, therefore, that the one valuable result of all our experience has been the selection of a few typical arrangements which we are now compelled to study, as minutely as circumstances permit, for the purpose of standardising and mechanically perfecting these particular types as standard machines, which will run as reliably as our stationary engines, and which can be manufactured as economically.

Taking up each of the factors of aeroplane-engine design that seem important in as specific a way as seems proper, the first one I wish to consider is the value of efficiency and the relation of efficiency to minimum weight.

Plotting hours of running as abscissæ against weight of engine, with fuel and oil, as ordinates, for the air-cooled and the water-cooled types of motor, respectively, so that the intercept on the vertical axis represents the weight of engine metal alone, and the ordinates away from the axis represent the weight of metal plus fuel and oil, one finds that the two curves cross at some period of running beyond which, therefore, the water-cooled heavier engine, because of its lower fuel consumption, becomes lighter in comparison.

The metal weight of the water-cooled motor is about one and a half times that of the air-cooled motor, and the slope of the combined-weight line of the latter compared with that of the former is as two is to one—that is to say, the consumption of the air-cooled motor is approximately twice that of the water-cooled motor. These facts are responsible for the crossing of the lines.

Of the conditions for efficiency which bear upon this question of fuel weight, and which have led to the selection of the water-cooled motor as a type, the first is the compression. The higher the compression the higher the efficiency, and there is no limit until preignition occurs. Statements will be found in text-books to the effect that there is a limit, but they are the results of mistakes in interpretation, and are erroneous. The amount of compression possible is limited, however, by the metal temperature and by the temperature of the mixture as admitted. Naturally, the warmer the mixture during suction, the sooner it reaches ignition temperature by compression. Therefore, suction heating is a limit. Again, the interior metal temperature, if it is high (as it is always), may cause trouble by contact with the mixture during compression, and some portion of the mixture may be brought to its ignition temperature by hot-wall contact long before the main mass is brought to this ignition temperature by compression alone. It requires only one such hot spot to wreck a well-laid plan.

The next factor in efficiency is the mixture quality, and in this there are the following controlling elements; First, mixture proportions. Any excess fuel means direct waste, but it also means carbonisation and fouling. Excess air quickly makes the mixtures practically non-burnable. Therefore, mixture proportions must be accurately controlled—more accurately than is possible with any existing carburetter. Carburetters are not yet satisfactory, and as soon as satisfactory carburetters are secured from the standpoint of proportionality of the mixture, we may expect to see a further reduction in fuel consumption and more reliable operation.

Dryness of mixture is a matter of co-ordinate importance with mixture proportions. When mixtures are wet—that is, not completely vaporised—the air and fuel cannot be uniformly distributed to the various cylinders by the manifold system. One cylinder will get a different charge from another, as can be easily proved by pressure gauges. There are rarely two cylinders alike as to maximum pressures on a multi-cylinder engine using wet mixtures. Drying of the mixture will cure that fault, and also cure the carbonisation that comes from the vaporisation of the liquid in the presence of the burning gas when it has been admitted to the cylinder in a liquid state.

The third factor of the mixture question is homogeneity. However accurately the mixture may be adjusted as to fuel and air ratio, however carefully the mixture may be distributed, cylinder to cylinder, the fact remains that, in order to produce economical results, the charge in any one cylinder must be uniform in every cubic inch of it. It is not sufficient that the right amount of air be in the cylinder, even if the fuel is vaporised when the latter is all in one corner.

Following mixture quality, the next factor in efficiency is rate of flame propagation with reference to piston speed. It can be shown that the explosion line of the indicator card following compression must be maintained vertical for maximum efficiency. Now, the rate of propagation is the one factor that tends to hold it vertical. If the propagation rate is high enough for a given piston speed, so that

* Abstract of a paper read before the American Society of Mechanical Engineers.

the explosion line is vertical, the efficiency will be high. But should the piston speed exceed a certain value, then the explosion line will begin to lean towards the expansion line, until by-and-by it becomes horizontal and merges into the expansion line, with a consequent large loss of work area and low efficiency or high fuel consumption. Therefore, there is for every given mixture a limiting piston speed that cannot be exceeded without destroying efficiency, and we are now approaching that speed in aeroplane engines.

The next related factors are mean effective pressure and speed. These are the prime factors for the output of a cylinder.

If the mean effective pressure were constant, then horse-power with reference to speed would follow a straight line. The mean effective pressure is not constant as the speed varies, however. Therefore, plotting horse-power against speed gives a curve having the general form of concave downwards and consisting of several separate portions, each worthy of study. There is usually a straight portion over a given speed range, during which the mean effective pressure is constant. For lower speeds the mean effective pressure is lower, and for higher speeds the mean effective pressure is again lower. From the point where, with increasing speed, the straight line becomes a concave-downwards curve, the mean effective pressure is decreasing as speed increases, until at the point where the tangent to the curve becomes horizontal, the rate of increase of speed is exactly equal to the rate of decrease of mean effective pressure. At a little higher speed mean effective pressure decreases faster than speed increases, and finally the curve drops down towards zero power.

*(To be continued).*

## TESTING FOR STEAM-RAISING EFFICIENCIES.

By F. R. Parsons.

It is indisputable that the boiler-house affords the greatest scope for the highest economies, for it is here that quite four-fifths of the total cost of producing power occurs. Whilst this is fully recognised by those whose sphere it is to design and supply plant for expeditiously and economically raising steam, it would appear that not all station engineers appreciate in a like degree the need for, or the importance of keeping themselves constantly assured that the plant under their care is being maintained at its original high standard of efficiency.

It has been suggested, often in the writer's hearing, that it is questionable whether the saving effected by installing the equipment necessary to systematically carry out the various tests in order to ascertain the tendency of the efficiency curve is of sufficient importance or magnitude to balance the outlay incurred. To this the answer nine times out of ten would be that if an increase in efficiency of 10 per cent only could be secured this alone should make the innovation worth while.

If we review the various tests necessary as coming within the scope of the steam-raising plant we find that broadly they are covered by:—(1) Boiler trials to determine quantity of water evaporated per pound of fuel; (2) pounds of water evaporated per square foot of grate area; (3) coal tests and comparisons for heating values; and (4) tests to acertain steam consumption where boiler feed and donkey pumps, and any auxiliary plant incidental to the demands of the boiler-house, are concerned.

### Water Evaporation.

Dealing first with the question of water evaporation, many engineers-in-charge rely on the information afforded by the use of one or more water meters—one, we will say, connected with the feed pipe, another dealing with the discharge to the hot well. This, we admit, gives a certain amount of information, but it is of too generalised a character to be valuable, it does not go either sufficiently far or deep enough for the engineer who is out for economies.

The least costly, though what, perhaps, might be deemed, at first sight, a rather expensive system initially to instal, whereby the steam-raising plant might be considered to be always and at any time in a condition for an immediate test, is the loop system of feed main, in conjunction with a measuring and a supply tank. This is shown diagrammatically in Fig. 1.

It should need little description to make this arrangement and method of operation clear.

As will be seen, the usual feed ranges to each boiler are connected to an auxiliary feed range, the latter drawing

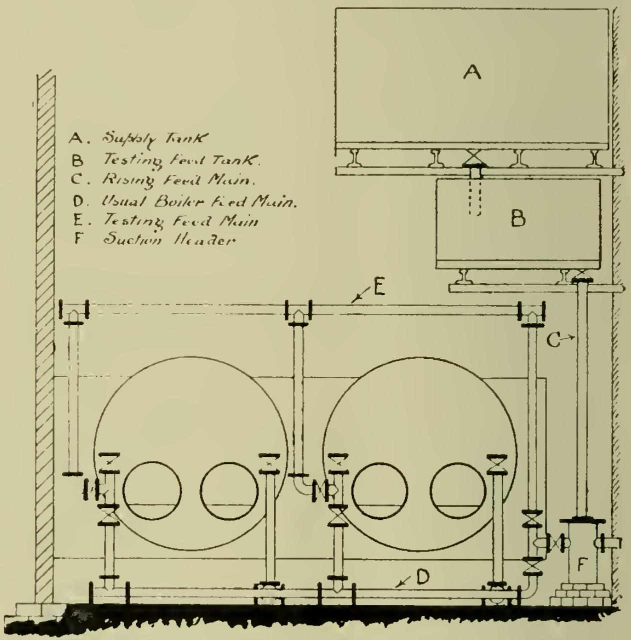



Fig. 1.—Lay out of Tanks, Connections, and Valves for Testing.

its supply, when under testing conditions, from the measured tank, this being served from the main supply tank above it. The feed pump draws from a single common header supplied from the test tank, thus one or both, or any number of separate or grouped units, can be tested or isolated at will merely by operating a series of by-pass valves. If the tank is carefully calibrated there is no actual need for the use of a water meter, though, obviously, the inclusion of such an instrument might very conceivably have certain definite advantages, not the least of which would be to obviate the necessity for measuring each supply of feed water.

### Coal Consumption.

It is always a good plan to keep a carefully-tabulated record of coal consumption. This, of course, means a coincidental survey also of steam consumption, for it is obvious that without some permanent and reliable record of distribution any data relating to production alone would be valueless and misleading. To assert that under

certain specific conditions a certain quantity of water can be evaporated per square foot of grate area might convey but extremely little, or even nothing, when extended over a period covering general conditions found in, say, twelve months' working.

Then again, certain fuels, to give the most economical results, require a considerably greater air supply than others, and, of course, different treatment in the furnace.

In this connection the writer can cite a case strongly bearing on the importance of this point. A certain mill owner had become suddenly obsessed with the idea that he would stand to reap a decided advantage in the matter of power output by substituting a much higher grade fuel for the medium grade he had been accustomed to use.

As a preliminary move the present writer was deputed to furnish calorimetric results of the respective fuels with a view to ascertaining their relative heating values. These tests showed that the new fuel possessed fully 20 per cent greater heating value in B.T.U.'s than the old, and its use was therefore decided upon.

A month's trial, however, of the steam-raising plant under the new conditions, conducted, it may be said, on thoroughly exhaustive lines, revealed the fact that an improvement of barely 5 per cent in the power output was being realised. The writer was, accordingly, called

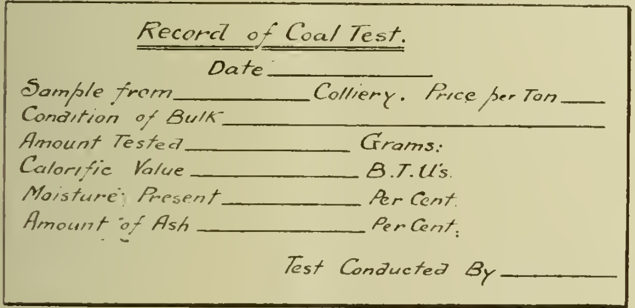

Record of Coal Test.
Date ____
Sample from ____ Colliery. Price per Ton ____
Condition of Bulk ____
Amount Tested ____ Grams.
Calorific Value ____ B.T.U's.
Moisture Present ____ Per Cent.
Amount of Ash ____ Per Cent.
Test Conducted By ____

Fig. 2.—Card for Recording Coal Tests.

in to advise. Under his recommendation a firebar of altogether different design was fitted to the furnaces, one that induced a more thorough and freer combustion, with the result that at the end of a further month the plant showed an appreciation of 13½ per cent.

The ascertaining of coal values from calorimetric tests to be of use in fixing steam plant efficiencies should be conducted with frequency and regularity, and at least at weekly intervals. Equally important is it when conducting these tests to keep a record of the amount of moisture and the percentage of ash contained in the samples; as these are factors of not a little importance when testing for efficiencies. It is suggested that all vital particulars concerning coal tests should be indexed on the card system, an example being offered at Fig. 2.

Engine-room test are, as a rule, separately conducted, and therefore scheduled apart from those coming strictly within the scope of the boiler-house, hence it is necessary, if the object is a survey of steam-raising efficiencies only, to determine what proportion of the steam generated when used in pumps, coal-handling plant, etc., is to be considered as a necessary adjunct to the plant.

Were this to be lost sight of, there might possibly exist between the one set of records relating to the boiler-house and that of the engine room a discrepancy which might easily become chargeable to the debit side of the steam-raising plant, and thus nullify all data referring thereto.

Periodical tests for chimney draught, and the percentage of $CO_2$ also are advisable. A good $CO_2$ record might or might not indicate either economical firing or perfect combustion, but in any case a reliable instrument will certainly denote the presence of undesirable air leaks in flues and uptakes—an important factor if the highest possible efficiency is the end in view.

## TREATMENT OF HYDROCARBON FUELS.*

By H. G. Chatain.

During several years of the early development of the oil engine the jet carburetter was, after many other types had been tried, brought out. This device had for its basic principle of operation the issuing of one or more small streams of gasoline into a rapidly-moving mass of air. The inertia of gasoline in conjunction with the moving body of air possessed sufficient force so that the liquid was, strictly speaking, mechanically broken up and turned from a liquid into what might be termed a fog. The design of this apparently simple piece of apparatus is indeed very complicated—so much so that in over 20 years with innumerable intelligent investigators working on the problem, it is still, although practical, far from being a comparatively perfect piece of apparatus.

It is well known that the gas formed by the mixture of air and gasoline fog is as highly explosive as possible when it is composed of 15 parts of air to 1 part of gasoline. This is proportioned by weight at atmospheric pressure. Above or below this figure the carburetion is not so good. Explosion, it is true, may occur, but its effect becomes mediocre, and obviously the power of the engine falls off. The disproportionate mixture may be carried to such a point that explosion does not occur at all. It is well known that the ratio 15 to 1 varies with the combustible used. For example, it is necessary to have 15 parts of air to 1 of gasoline, but only 9 parts of air to 1 part of ethyl alcohol, 7 parts of air to 1 part of methyl alcohol, and so on for the various fuels. Therefore, if the carburetion of the air by the fuel is to be as good as possible, it is necessary that the proportions mentioned be kept constant through the range of speed, load, and combinations of the motor. The changes in speed and in load produce a radical varying effect upon the carburetter, as the varying amount of air aspirated decreases or increases the depression or drop in pressure at the gasoline jet. Compensating for this varying depression has never been solved in an entirely satisfactory manner.

The first question that has confronted the constructor has always been this curious feature of the carburetter—that is, to find a practical mean between gasoline and air at various speeds, loads, and combinations. The operator cannot be asked to make running adjustments by hand, therefore it is necessary, first, to find a means to make permanent the proper ratio, and, second, to charge the motor with keeping this permanency of mixture. It was at first thought that this ratio of 15 to 1 would necessarily stay constant, even with the variations in the functioning of the motor, and that the relative value of the depression caused by the aspiration of the motor would remain constant with relation to the gasoline and keep the proper proportions, the orifices admitting the air and gasoline to remain fixed.

This assumption was an error. Air is a gas and gasoline is a liquid, therefore, the masses of the two bodies are not

* Abstract of paper read before the Society of Automotive Engineers, New York, May 17th, 1917.

equal, and consequently the inertia of each is unequal. After the liquid is put in motion by the depression in the intake pipe, it has an inertia greater than that of air; therefore, the liquid will continue to come out of the orifices a moment or two after the load has been thrown off or the speed of the motor reduced, while, on the contrary, the air issuing through the orifices in the vicinity of the gasoline jet ceases instantly, or nearly so, upon the reduction of speed or load of the motor. The permanency of the ratio would exist without any special apparatus if we were dealing with two gases, for instance, air and illuminating gas or natural gas. The mixture of the two gases would have an inertia quite the same,. and they would come out of the respective orifices in a fixed proportion, once they were adjusted for various speeds and loads of the motor.

The conclusion was arrived at that with this type of carburetter some device would have to be utilised to admit more or less air and thereby increase or decrease the depression in the intake pipe, so as to keep the ratio in the proper proportion. Hand regulation of the device mentioned was at first resorted to, but this was found to be impracticable, as one never knew exactly when the carburetter was adjusted so as to maintain the proper proportion of 15 to 1, with the net result that at times the engine ran properly, but oftener it did not.

It is probable that the market price of gasoline has been, up to the present year or so, comparatively so low as to discourage endeavour in the field of utilising kerosene or heavy hydrocarbons such as fuel oil, various crude petroleum, tar oil, etc. However, conditions are changing and will change so as to make it imperative that some other combustible than gasoline be used. Since most lines of endeavour are conducted along the path of least resistance, it would seem that the next combustible to be utilised will be kerosene. This brings us to a consideration of what has actually been accomplished in the utilisation of kerosene.

The demands to solve the problem of utilising kerosene have resulted in certain distinct types of devices, which are as follows: (1) The commonly-accepted type of gasoline-jet carburetter with heat applied in various ways: (*a*) To the fuel itself; (*b*) to the air; (*c*) heated jacket; (*d*) heated jacket plus heated intake pipe. (2) Devices that will partly burn the fuel before it is admitted to the intake pipe, forming a more or less fixed gas intermingling to a greater or less extent with the vapour of the combustible. (3) Devices that admit the combustible in the cylinder direct, the valves of the motor being so regulated as to cause a partial vacuum in the cylinder prior to the admission of the combustible. (4) Where the combustible is impinged, by means of a pump or otherwise, directly upon a hot surface in the interior of the cylinder or a chamber adjacent thereto. (5) Devices that raise the temperature of the combustible to the boiling point, producing vapour but in no sense of the word a fixed gas.

(1) To criticise the endeavours formulative of the first group is a comparatively simple matter. Primarily, the forces manifest in the gasoline carburetter are absolutely insufficient to turn kerosene into a fog, or rather put it in a condition such that it would commingle with the oxygen in the cylinder and be readily inflammable. Secondly, the source of supply of the heat is inconstant, and is difficult to regulate. Its action lags—that is to say, when a sudden demand is made upon the motor for increased combustible the heat requisite is not available until the combustible is actually burnt, therefore sudden variations in load and speed cannot be well taken care of by this process. In starting the motor it is necessary to derive heat from an exterior source. This is inconvenient, however, and for stationary engines, certain classes of boats, or other applications, where a skilled attendant is available, this type of gas-making device has had and is having success.

(2) The second type, or what might briefly be called the fixed-gas type, presents many attractive features. In starting all that is necessary is to ignite, by means of a wick, part of the combustible, no other preheating being necessary. With proper regulation of the amount of fuel actually ignited and relying upon the aspiration of the motor, a reasonably permanent gas can be formed and regulated under the adverse conditions under which we are working. The writer has operated a device of this character in extremely cold weather with gratifying results. We certainly may look forward to further developments.

(3) A device utilising this principle was experimented with to some extent by the writer, and although it was possible to start an engine cold, the cycle of events occurring in the cylinder was so divergent from normal, owing to the very late opening of the intake valve, that the experiments were discarded, and no great amount of work was done along these lines; also for the reason that the scheme introduced what appeared to be excessive complication.

(4) This method of utilisation of combustible is well known. It has the insurmountable fault that it is necessary to preheat the engine; this, it would appear, can be done in a practical manner only by means of some form of blow torch, requiring several minutes to heat the parts sufficiently to make starting certain. If a multi-cylinder engine, such as the prevailing types of the day, were used, the complication and trouble would make the scheme highly undesirable.

(5) About the same criticism can be made for this scheme as for No. 4. It is hardly worthy of further investigation for our purpose. The idea has about all of the attendant disadvantages of the steam boiler with a few added.

*(To be continued.)*

## THE CONDENSATION PUMP: AN IMPROVED FORM OF HIGH VACUUM PUMP.

By Irving Langmuir.

*(Concluded from page 415.)*

### Theory of the Operation of the Condensation Pump.

For a number of years the writer has been convinced that the collisions between gas molecules and a solid or liquid body against which they may strike, are in general almost wholly inelastic. Each molecule which strikes a surface thus condenses on the surface instead of rebounding, although it may subsequently re-evaporate. This condensation takes place just as well at high temperatures as at low, but at high temperatures the re-evaporation may occur so soon that it is difficult to detect the condensation. In this case the condensed molecules constitute an adsorbed film. The condensed particles, before they re-evaporate, are held to the surface by the same kind of forces as those which hold solid bodies together. This leads to a theory of adsorption which is in excellent agreement with experimental facts. It was by a direct application of these ideas that the writer was led to construct a high-speed mercury-vapour pump.

The author then describes the operation of Gaede's diffusion pump. The principle underlying the action of this pump prevents rapid action, and realisation of this fact led the author to construct the type of pump shown

in Fig. 1. The very first pump constructed operated perfectly satisfactorily, and gave a speed of about 1,800 cubic cm. per second. The action of the pump is based on radically different principles from that of the ejector. The most essential element in the operation seems to be the condensation of the mercury vapour at K, and the maintenance of a temperature in this region so low that the condensed mercury does not re-evaporate. It is, therefore, suggested that pumps based on this principle should be called condensation pumps.

The distinction between the condensation pump and the ejector is clear when we realise that in the ejector there is no necessity for cooling the walls of the tube, whereas the condensation pump entirely fails to operate unless this is done.

If this later form of pump is examined during operation, it is seen that when there is a high vacuum on the intake side of the pump, practically no condensation of mercury takes place on the walls of the condenser C above the level of the point P. In other words, all the atoms of mercury vapour leaving the end of the tube L have downward velocity components, and therefore cannot pass up above the point P unless they first strike some body not having the corresponding downward velocity. If, however, the walls of the condenser are allowed to become heated then the mercury atoms from L collide with mercury atoms evaporating from the walls (which do not have downward velocity), and as a result of these collisions a large faction of this mercury vapour is deflected upward into the space E. This prevents gas from F from reaching the point P, where it might be acted on by the direct blast from L.

Where a small flow of gas is allowed to enter through R, so that the intake pressure is maintained at about 100 bars, it is interesting to observe that the line of demarcation below which the condensation occurs loses its sharpness, and that a considerable quantity of mercury vapour condenses above the point P. This is due to the collisions between the mercury atoms from L and the gas molecules, which are driven in close to the walls of the condenser C.

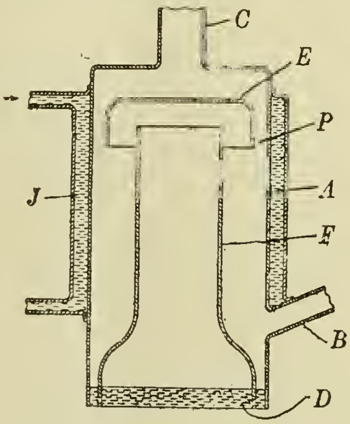
Another interesting fact may be observed by watching the operation of the condensation pump. The greater part of the mercury vapour which escapes from L condenses on the walls of C within a couple of centimetres below the end of the nozzle L. This indicates that the mercury atoms radiate out from the end of L in all directions, and show no particular tendency to continue to move in the direction in which the nozzle is pointed. This is essentially different from what happens in injectors or ejectors. It is well known that when steam escapes from a straight tube into the open air, the jet of steam continues to move in a nearly straight line for a considerable distance from the nozzle before it mixes to a large extent with the air. This effect evidently entirely disappears at very low pressures. This fact is in accordance with the kinetic theory of gases. At very low pressures the density of the mercury vapour is extremely small, whereas the viscosity of the gas is practically as great as at atmospheric pressure. The frictional effects of the walls therefore entirely predominate over the inertia effect which at higher pressures leads to the jet formation.

Some special pumps have been built to operate by a combination of the injector and condensation pump principles, so that very much higher exhaust pressures may be used. In this way it has been possible to operate a single mercury vapour pump producing as high a vacuum as the ordinary type of condensation pump, but exhausting at a pressure of about 20 mm. of mercury. Further development work will be necessary, however, before these pumps become as satisfactory as a condensation pump backed up by a mechanical pump.

### Condensation Pumps Built of Metal.

The condensation pump lends itself admirably to construction in metal. One type of pump which has proved relatively simple in construction and efficient in operation is shown diagrammatically in Fig. 2. A metal cylinder, A, is provided with two openings B and C, of which B is connected to the backing pump, and C is connected to the vessel to be exhausted. Inside of the cylinder is a funnel-shaped tube F, which rests on the bottom of the cylinder A. Suspended from the top of the cylinder is a cup E, inverted over the upper end of F. A water-jacket J surrounds the walls of the cylinder A from the level of B to a point somewhat above the lower edge of the cup E.

Mercury is placed in the cylinder as indicated at D. By applying heat to the bottom of the cylinder the mercury is caused to evaporate. The vapour passes up through F and is deflected by E, and is thus directed downward and outward against the water-cooled walls of A. The gas entering at C passes down between A and E, and at P meets the mercury vapour blast, and is thus forced down along the walls of A, and out of the tube B. The mercury which condenses on the walls of A falls down along the lower part of the funnel F, and returns again to D through small openings provided where the funnel rests upon the bottom of the cylinder. (A more detailed drawing of the pump as actually constructed is shown in the original article.)



The Condensation Pump.—Fig. 2.

Pumps of this type have been made in several different sizes. A pump in which the funnel F is 3 cm. in diam. and the cylinder A is 7 cm. in diam. gives a speed of exhaustion for air of about 3,000 cubic cm. per second, and will operate against an exhaust pressure of 200-600 bars, depending on the amount of heat supplied to the mercury. The energy consumption ranges from 100 to 500 watts. Very small pumps have also been constructed in which the tube F is only 0·6 cm., and the cylinder A is only 2 cm. in diameter. This type of pump gives a speed of about 200 cubic cm. per second.

### Degree of Vacuum Attainable.

The condensation pump resembles Gaede's diffusion pump in that there is no definite lower limit (other than zero) below which the pressure cannot be reduced. This is readily seen from its method of operation. A lower limit could only be caused by a diffusion of gas from the exhaust

side (N, Fig. 1) back against the blast of mercury vapour passing down from L. The mean free path of the atoms in this blast is of the order of magnitude of a millimetre or less, and the blast is moving downward with a velocity at least as great as the average molecular velocity (100 metres per second for mercury).

The chance of a molecule of gas moving a distance of about 4·6 times the mean free path without collision is only 1 in 100. To move twice this distance the chance is only 1 in $100^2$, etc. If the mean free path were 1 mm. the chance of a molecule moving a distance of 4·6 c.m. against the blast without collision would be 1 in $10^{20}$. In other words, an entirely negligible chance. However, if with any particular design of pump it should be found that gas does leak back against the blast of vapour, it is a simple matter to increase the pressure in the blast or increase the distance against which the gas must pass back through the blast. Thus, the construction adopted in Fig. 1 may be adopted where only a small part of the mercury is condensed close to the nozzle from which the vapour escapes, while the greater portion travels a considerable distance before condensing.

As a matter of fact, even in the type of pump with a single condensing chamber such as shown in Figs. 1 and 2, there is evidence that the back diffusion is absolutely negligible under all normal operating conditions.

Of course, it must be realised that the condensation pump like any mercury pump does not remove mercury vapour from the system to be exhausted. The vapour pressure of mercury vapour at room temperature is in the neighbourhood of two bars. By inserting a trap such as that indicated at G (in Fig. 1) between the pump and the exhausted vessel this vapour pressure may be lowered.

For a very large number of experiments the presence of mercury vapour is not injurious. By use of solid $CO_2$ or liquid air the mercury vapour may be entirely eliminated.

As has been pointed out previously, the vacuum actually attainable by the condensation pump is usually determined by the rate at which gases are given off by the walls of the vessel being exhausted.

By means of a new type of vacuum gauge devised by Dr. A. W. Hull, of the research laboratory, pressures as low as $10^{-5}$ bar obtained by the condensation pump have already been measured. There is little doubt but that pressures very much lower than this can be and have been obtained by cooling the bulb to be exhausted in liquid air, so as to decrease the rate at which gases escape from the walls.

*(Concluded.)*

## MILITARY INFLUENCE ON MOTOR TRUCK DESIGN.*

By H. D. Church.

Motor trucks of American manufacture have played an important part in the present European War, but up to this time our general design has not been materially influenced thereby.

The conditions on the Western battle front in Europe are such that large armies have been practially in the same positions for two years, and this fact, in conjunction with the first-class French roads, has made it possible for the conventional design of American commercial motor trucks to render fairly good service.

In other words, the commercial motor truck of to-day is essentially a hard roads vehicle, and when used over such roads, would naturally not require any radical changes in design to meet military conditions.

In event of any fighting on American soil at any time for several years to come it is most improbable that similar conditions to those outlined above would exist. Our borders are so long that permanent trench fighting on a large scale is most improbable, and the roads in this country are far inferior to those of France or Germany. It follows, therefore, that a truck designed for satisfactory military operation in this country, which means for use in connection with mobile field operations over mediocre roads, or, in come cases, no roads at all, must necessarily be of a design differing in many respects from our present type of commercial vehicle. Furthermore, the design of such a truck is bound to be influenced by the widely-varying climatic conditions found in the United States proper.

During the trouble with Mexico, in the past year, our army, for the first time, depended almost entirely upon motor transport, using quantities of the leading American makes of conventional commercial trucks.

From the standpoint of quick development of a suitable truck for American army use, it is most fortunate that the operating and climatic conditions were extreme, as the result was to define sharply those points wherein a truck designed primarily for commercial service would not satisfactorily meet our military needs.

The experience of our army with motor transport for the past several months has resulted in a vast amount of information as to desirable changes in design, and the army has been most willing to extend to the engineers of the various truck manufacturers every facility to gather first-hand information on army requirements for motor transport.

It is the writer's opinion that for American army transport purposes several different types of transportation will be required, according to topographical and road conditions:—

1. Mule transport.
2. Caterpillar tractors.
3. Four-wheel driven trucks.
4. Two-wheel driven trucks.

Each of these methods of transport will probably be used, as each of them has a certain field of operation which cannot satisfactorily be filled by the other types. It is probable that the majority of the transport work will be done with two-wheel driven vehicles, as, where the road conditions will permit of its passage, this type will haul materials in the minimum time and at the minimum operating expense. As the writer's direct experience has been largely with two-wheel driven trucks, this paper will be confined to consideration of that type, primarily of a nominal capacity of 1½ tons, this being the size which was most largely used in the military operations in Mexico.

### Governors.

One of the first and most important points in connection with the design of a military truck is the absolute necessity for governors on the motors, not only to limit the maximum vehicle speed on high gear, but also to limit the maximum motor speed on any of the gears.

Experience along the border with trucks which had never been equipped with governors by their manufacturers, as well as with trucks on which the governors had been removed to obtain more power, proved conclusively that a governor is even more necessary for trucks in army service than for those in commercial service.

* Paper read before the Cleveland Engineering Society (U.S.A.).

From personal observations made along the border, it is the writer's opinion that the constant maximum motor speed governor is the proper type. This type of governor not only keeps the maximum vehicle speed down to a point where durability is assured, but it also keeps the motor speed down at all times, so that it is impossible to shorten the life of the motor by excessive speed when running on any of the geared speeds in the transmission. This is an important consideration for soft road operation, where, if a governor which limits only the maximum road speed is fitted, there is a great temptation to the driver to run for long periods on second or third gear in the transmission with the motor racing, a practice which will materially shorten the life of the motor.

Governors must be thoroughly enclosed and sealed, to prevent their being tampered with without the knowledge of those in authority, and in order to obtain the best results should be extremely sensitive, without "surging." A sluggish governor cuts into the power curve of the motor too early on acceleration and too late on deceleration, and experience has shown that a snappy governor action can be obtained within speed limits of 4 per cent on acceleration and 6 per cent on deceleration, which will utilise the maximum amount of horse-power for a given maximum governed speed.

### Ability or Tractive Effort.

Consideration of governors leads directly to the question of ability or tractive effort, both on high and low gears. To obtain the best results over soft road conditions, and without disconnection of governors, the average American commercial truck has insufficient high gear ability and far too little low gear ability successfully to pull its load through deep sand or mud or over extreme grades.

The average truck designed for American commercial service has plenty of ability on both high and low gears to handle successfully its load over hard roads and over the grades found in American cities, but the conditions of operation for army service in this country are much different.

The tractive effort required increases very rapidly with an increase in road resistance, and sand or soft going will not infrequently result in road resistances as high as 300 lbs. to 500 lbs. per ton, far in excess of anything ordinarily encountered in commercial service. When it is considered that the road resistance in pounds per ton on good asphalt is 15, on macadam 50 to 60, and over ordinary cobbles 130, the necessity for an increase in tractive effort becomes very apparent.

For American military purposes the low gear tractive effort should at least be sufficient continuously to turn the rear wheels of the fully-loaded truck on dry asphalt with the truck itself stationary. Using a coefficient of friction between the tyres and a dry asphalt surface of 0·6 and a total rear end loaded weight of 7,600 lbs. for a $1\frac{1}{2}$-ton truck loaded to capacity, the low-gear tractive effort necessary to meet these requirements becomes 4,560 lbs.

Commercial truck practice now gives far lower figures. For example: The low-gear tractive effort of what is considered a powerful $1\frac{1}{2}$-ton commercial service truck is only 2,600 lbs. To carry safely the low-gear torque required to give 4,560 lbs. tractive effort, the driving members throughout, from the gear train in the transmission clear back to the rear tyres, must be made heavier and stronger, which, of course, will result in an increase in chassis weight. From the standpoint of design it is probable that any such increase in low-gear ability for military service, as outlined above, will cause more changes in truck chassis design than any other one requirement, the necessity for which became apparent during last year's experience on the border.

### Motor Cooling.

The heat-dissipating ability of the average radiator was found inadequate, a serious matter at any time, and more serious in a country where water is scarce. With the thermometer standing at 110 deg. to 120 deg. in the shade and the truck using maximum motor-power on low gear for long stretches, extraordinary motor-cooling ability is required. Probably an increase of 50 per cent over average commercial practice would not be excessive, and a desirable provision would be a simple means for reducing the radiating area for efficient use in the cooler sections of this country.

When a truck is pulling along through heavy sand on low gear its speed is so slow that the air circulation through the radiator resulting from the movement of the vehicle can practically be disregarded. This means that the radiator fan must handle a large volume of air in order to keep the motor cool under these conditions. In the writer's opinion, this is not so much a question of efficient fan design as it is of furnishing some means of driving which will keep the fan up to its normal operating speed. The belts used for driving the fans on the average commercial truck are not sufficiently powerful properly to meet this condition, and either the size or design of belt will have to be changed, or some positive drive provided for the fan.

This is an important point, for if the radiator design is such that it depends upon the fan circulation to give a certain cooling ability, the result is seriously affected if the fan does not at all times draw approximately the volume of air that it handles when its belt is new and tight. A feature of the radiator which should be given careful consideration is its mounting, which should be such as to minimise any strains in the radiator proper which are set up as a result of excessive chassis-frame deflection. Furthermore, the radiator should be of a type which has large water passages, is least liable to break under distortion, and which is readily repairable in the field.

### Transmission Gears.

Army experience on the border clearly showed the desirability of four-speed instead of three-speed transmissions for military purposes. If the low-speed reduction ratio in a three speed transmission is made great enough to give proper low gear tractive effort, the steps between speeds become so great as to interfere with easy gear shifting. Furthermore, the four-speed gear-box has the very important advantage over a three-speed box for soft road service of always having a gear ratio more nearly adapted to any particular road requirement than can be obtained in a three-speed box.

It is probable that the gear ratios in a four-speed box for military trucks will be so arranged that second speed will be used for normal starting on hard road surfaces, and that the first speed, or low gear, will have a greater reduction ratio than anything which has been built to date. This high reduction ratio low-speed gear will then be in reserve for starting or running in deep sand or mud, or for climbing steep grades. In effect, such a combination of gear ratios would practically result in adding to a three speed gear-box of the conventional ratios an extra low gear with an extremely high reduction ratio, to be used for starting or running in sand or mud or for climbing steep or soft grades.

### Control Elements.

The desirability of standardising the control elements has been clearly indicated. When large fleets of trucks are operated by a single user, particularly if the trucks are kept in operation for more than 10 hours or 12 hours out of 24, two shifts of drivers are necessary, and there is bound to be a certain amount of shifting of drivers from one make of truck to another. Where drivers are called upon to drive different makes of trucks, they should be able to do so with facility, and much time would be saved, and better average operation assured, if the same motion of the driver's right or left hand or foot could produce the same result irrespective of the make of truck. Standardisation of controls along these lines would not only result in more economical and efficient operation, but would also simplify the instruction of drivers.

### Wheels.

The use of all-metal wheels will undoubtedly receive careful consideration as a result of border experience, in spite of the fact that the wood wheels with which the majority of trucks were equipped gave remarkably good service. For desert running in the northern Mexican or south-western United States climates, any wood wheel, no matter how good, will eventually loosen in the spokes, and all-metal wheels are essential for durability in such climates.

On commercial trucks of three tons capacity and under steel wheels are not extensively used, due probably to the fact that for normal service wood wheels are perfectly satisfactory, and also because a set of steel wheels for a truck of two tons capacity or less will weigh approximately 125 lbs. more than the corresponding wood wheels. For military service, however, which is bound to be extreme, any objection from the standpoint of slightly increased weight is more than offset by the necessity for durability under any climatic condition.

### Wheel Gauge or Tread.

Wheel gauge or tread is most important when numbers of trucks of different makes and sizes are operated over the same routes on soft roads, and trucks for American army service ought to have a specified standard gauge in order that each different size or make does not have to break down a new track in the roadway.

If all sizes of trucks could be made to the present standard road gauge of 56½ in., such standardisation would be of the utmost value from a commercial as well as a military standpoint, as it would facilitate the operation of all trucks over soft country roads. Such a narrow gauge is impracticable for large trucks from three tons capacity and up, owing to constructional limitations. It would appear, therefore, that the best compromise from a military standpoint would be to ascertain how narrow it is practicable to make the gauge of the larger trucks and then to increase the gauge of smaller trucks to a point where their tyres will run within the tracks made by the wider tyres of the larger vehicles.

From a commercial standpoint this plan would slightly impair the usefulness of the smaller-sized trucks on soft roads, but if the gauge finally decided upon is not so much above 56½ in. that the wheels on one side can obtain no advantage at all from one of the 56½ in. tracks on the road, the objection is not serious, while any approach to a narrower gauge on present-day large commercial trucks would somewhat help their performance over soft roads. Such a standardisation of wheel gauge would be of immense value on trucks for military purposes, and, in the writer's opinion, would probably tend to increase the field of profitable operation for commercial trucks.

### Final Drive.

It is evident that the best results will be obtained from some form of fully-enclosed final drive, which should be so thoroughly enclosed as to retain lubricant, and to prevent deposit of fine dust or grit on any of the working parts.

Whatever form is used, either worm, internal gear, or double reduction, it should, in addition to the above requirements, be capable of efficiently and continuously transmitting the maximum low-gear torque of the vehicle without overheating, and give at least 10 in. road clearance with 36 in. diameter tyres.

A highly desirable feature would be the use of some form of differential which will automatically prevent one wheel from spinning if it loses traction, and which will still function as a differential when the truck makes a turn.

The torque-transmitting members throughout the rear axle, and through the entire driving train as well, should be able to stand, without overstressing, the sudden engaging of the clutch with the transmission in low gear, the motor running at maximum governed speed and the truck rear wheels locked.

### Brakes.

The development of a braking system suitable for a military truck presents severe problems in regard to cooling. The brakes as used on our commercial trucks of to-day are not well enough cooled to stand up long under some military conditions, as for instance, handling the fully-loaded truck on a three-mile descent on a hard road surface with grades running up to 25 per cent and averaging 7 per cent.

Brakes as designed have sufficient power to hold the truck under such conditions, but will heat up so that the linings char slightly and wear rapidly. Water cooling is undesirable, and it is probable that some type of metal-to-metal brake will be necessary, which, while not as smooth in action as, and noisier than, the conventional brake faced with brake lining, will give greater durability under continuous application.

### Dust Protection.

It is essential that thorough means be provided to keep dust and grit out of all working parts. Troubles from dust are more liable to result on trucks in military service than on those in commercial service, due to running in "fleets," or trains, over country roads.

Along the Mexican border, during the dry season, which means for the greater part of the year, there is an extraordinary amount of very fine, powdery dust, and a "train" of trucks running at 12 miles or 14 miles an hour will raise a dust cloud which is visible for miles. This fine dust is drawn into the motor cylinders through the carburettor intakes, acting as an abrasive on the pistons, piston rings, and cylinder walls, and some is apparently drawn into the crank-case through the breather, mixing with the lubricating oil and causing undue wear on all working parts of the engine. Some form of separator or air strainer for both the carburettor and breather would be highly desirable, but it should be of a simple type, not requiring too frequent cleaning, and should not be of any form requiring water.

### Road Clearance.

On a military truck the question of road clearance is of great importance. Not only should a minimum clearance

of 10 in. at the centre of both the front and rear axles be maintained, but the clearances under the steering knuckle levers and the steering cross-tube ends must be as great as possible. Furthermore, unusually high road clearance is desirable under the chassis, midway between axles, to prevent contact with the ground when the truck is driven over a bank into a river bed or over a ridge.

### Results of Frame Distortion.

To take care of excessive frame distortion, which is unavoidable when operating over rough or soft roads, the radiator, motor and transmission, should be carried on three-point suspensions, and with clearances sufficient to obviate any possibility of their being themselves distorted. Provision should be made to protect the steering column from any binding from the same cause, and all connections between the rear axle and frame should be arranged to permit the maximum horizontal misalignment between the two without overstressing or breaking any of the connecting members. The gasoline tank mounting should also be carefully arranged to protect the tank from twisting strains.

### Conclusion.

It is impossible, without writing an unduly long paper, to take up all the points in the design of our conventional trucks which will be more or less influenced by military use.

Many other points will be affected, such as motor-lubricating systems, carburettor design, steering gears, springs, body design and attaching means, etc., but the points discussed above are, in the writer's opinion, the ones which will require the greater changes in design to render our commercial trucks suitable for military use in this country.

The War Department has made a careful analysis of motor transport, and is now drawing up a specification to cover a desired design of two-wheel driven trucks for service with our army. It is improbable that any subsidy plan for military trucks, similar to the English War Department subsidy plan, will ever be put into effect in this country.

In the absence of such a plan, it is probable that the United States War Department specification, when issued, will stand as a sort of master specification for American truck manufacturers, in that, as they bring out new models from time to time, they will incorporate in the design such features specified in the War Department specifications as will not detract in any way from the commercial value of the truck, and, at the same time, so design the other parts that with minimum change modifications could be added to meet the balance of the specification. If this procedure be followed, the War Department will eventually be able to purchase, at comparatively short notice, trucks which much more nearly meet its requirements than anything on the market to-day; and furthermore, many of the features found necessary from army experience on the Mexican border will, if incorporated in our commercial trucks, materially enlarge their operating field.

Electric Power in Canadian Mines.—Addressing the shareholders of the Mond Nickel Company at the third general meeting, the chairman, Mr. Robert Mond, J.P., referred to the Lorne Power Company in which they held all the shares, and said it had successfully put into operation a new power plant at Nairn Falls, on the Spanish River, which, as the shareholders were told last year, was in course of erection, and provision had been made for all the electrical power required for the increased output in Canada.

## TEXTILE MILL ELECTRIFICATION.

### Electrification of the Dunlop Rubber Co.'s Cotton Mills, Rochdale.

It cannot be gainsaid that there is no name which comes with a greater air of familiarity to the world than that of Dunlop, and the Dunlop-tyre industry is one which is of particular interest from many points of view. It is a habit

Textile Mill Electrification.—Fig. 1.

characteristically British that, having presented the world with a solution to a vital problem, we have contented ourselves with our achievement and left the development of our invention to the foreigner. But in the case of the pneumatic tyre nothing is more remote from the facts of the case. Since the Dunlop tyre was invented in 1888, not only has the manufacture of the highest class pneumatic tyres been kept in this country, but, in addition, the Dunlop

Textile Mill Electrification.—Fig. 2.

Company have left no stone unturned to promote the highest quality and reliability in their manufacture, so that the Dunlop tyre has ever been in the van of progress, and has never been indebted to the outside world for help to maintain its position in the front rank. Particularly has this been the case with the rapid development of the motor industry calling for a wholly new form of tyre.

Textile Mill Electrification.—Fig. 3.

## Motor Tyre Fabric Mills.

So far, no better criterion of the progressive policy of this Company can be found than the latest of their ramifications, the Dunlop Rubber Cotton Mills at Rochdale, where the Company have laid down an important works for the purpose of manufacturing their motor-tyre fabric direct from the cotton.

No matter from what aspect these works be viewed, whether it be from that of a thoroughly well-organised mill, or the quality of the textile plant installed, or the conditions under which the operatives work, or the excellence of the driving installation—whichever it be, it can only be said that the works leave no room for improvement. Moreover, the measures adopted for attaining these desirable consummations have been so well blended together that they do not confuse each other, and the whole forms a manufacturing scheme conducive to the highest efficiency at every point.

## Spinning and Weaving.

The works are divided into two distinct parts, one devoted to the spinning of the yarn from the cotton and the other for the manufacture of the fabric from the yarn. The total area occupied by these premises is 33,000 square yards. An inspection of these works keenly impresses the visitor with the efficient organisation, enabling the material to be dealt with rapidly right from its reception to its despatch.

Textile Mill Electrification.—Fig. 4.

## Lighting and Driving.

For the purpose of lighting and driving in this mill, electricity has been exclusively adopted, there being an aggregate of 2,500 H.P. of Witton motors and approximately 1,360 Osram lamps with an average candle-power of 40. The total number of operatives is nearly 1,000.

Electrical power is derived from the mains of the Rochdale Corporation at a pressure of 6,000 volts three-phase, being transformed down and distributed throughout the works at a pressure of 400 volts for power, and 200 for lighting. The question of the driving of textile mills is one which in the past has considerably exercised the minds of textile mill engineers. A great number are agreed upon the merits of electricity as against steam driving, but where agreement has not been so pronounced lies in the merits of individual against group driving. The management of the Dunlop Rubber Cotton Mills has not favoured the completely individualised drive, and the mill has been laid out on the plan that isolated machines shall have their own drives, while, where large groups of machines have to be driven in the same room, the textile plant is separated into a number of small groups, each of which is driven by its own motor. The result has been to combine the merits of individual and group driving, taking advantage of the merits of each system, and a thoroughly efficient system of driving has been obtained.

Textile Mill Electrification.—Fig. 5.

Except in one or two special instances where the presence of "fly" is more pronounced the semi-enclosed type of induction motor has been adopted, but, at the same time, wherever possible, the various rooms in which groups of identical textile machines are installed are operated from motors contained in special motor-houses or corridors running parallel with the length of the rooms. Views of these motor corridors are appended, and it will be seen that the machines are started by auto-transformer starters or rotor-starters, as the circumstances may demand, and convey their power to the shafting through chain drives. In some instances where the driving plant is remote of access from one of the corridors, special small cabins have been erected in the main rooms to contain the driving motors. The motors installed vary in size from 150 H.P. downwards.

## Reducing Labour Costs.

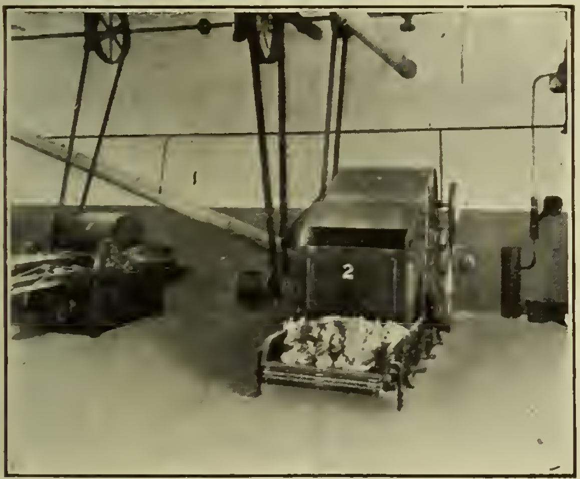
Every opportunity has been taken in these works for the reduction of labour costs by the utilisation of electric plant. When the raw cotton arrives, it is handled by a hoist driven

by a Witton motor. When the finished fabric takes its departure it is deposited into the truck by a similar device.

The adoption of electric driving has enabled the excellent arrangement of the mill plant to be shown to its best advantage. The individual machine stands compactly with its motor and starting panel, and can be operated independently of the rest of the plant. If any repairs on the textile machinery need to be made, or if it be necessary to run an individual machine when the rest of the mill is shut down, there is no question of detaining an engine-room staff. The man in charge of the work has but to operate the switch pertaining to the particular machine or group of machines he wishes to run. The spick-and-span cleanliness of the whole place cannot fail to attract attention. Even in those rooms where there is inevitably a considerable amount of "fly" created, no more than a small accumulation is to be seen. Naturally, with the adoption of electric drive, the shafting and belting common to the steam-driven textile factory has been largely eliminated, which contributes considerably to the promotion of cleanliness.

### Some of the Driving Arrangements.

Particularising a few of the drives, the raw material on entering and the finished fabric on leaving is handled by 7 cwt. landing hoists, driven by 6 H.P. "Witton" motors.



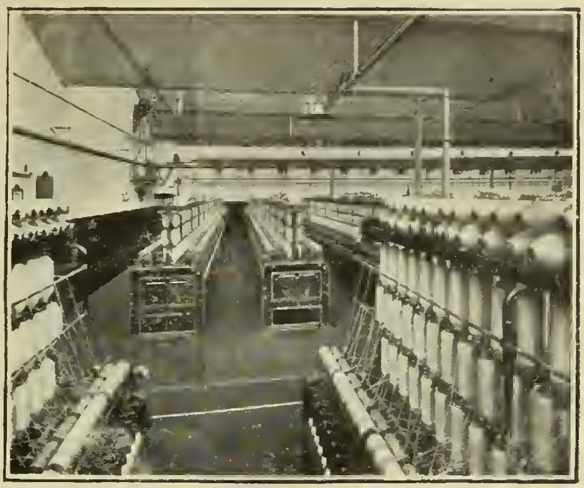
Textile Mill Electrification.—Fig. 6.

These hoists are controlled from a point near to the door by operating handles. A view of one of these hoists is given in Fig. 8. The hopper feeders depicted in Fig. 6 are individually driven by 6 H.P. "Witton" motors. The broken cotton is swept to the subsequent process by a current of air passing through the pipes seen in the illustration and produced by a pan driven by a 6 H.P. "Witton" motor. The bale breakers seen in Fig. 4 are driven by 20 H.P. "Witton" motors.

Fig. 1 shows the winding and warping room, and Fig 3 the hopper feeders and scutchers driven by 20 H.P. "Witton" motors.

Coming to the first of the corridors, which is shown in Fig. 2, this contains two 150 H.P., four 40 H.P., and two 20 H.P. "Witton" motors, driving the various groups of carding machines, slubbing, intermediate, roving and ring spinning frames, and so forth. Among the individual drives located in the main spinning room a typical example is shown in Fig. 7, which, in addition to giving an idea of the excellent general arrangements, shows two 6 H.P. "Witton" motors driving humidifiers

A further instance of the individual drive is the fabric-



Textile Mill Electrification.—Fig. 7.

stretching and examining machine depicted in Fig. 5, which is driven by a 20 H.P. "Witton" motor.

Sufficient has been said to indicate the completeness of the arrangements for the production of a first class article. With its 2,500 H.P. of "Witton" motors and its 1,360 Osram lamps, it is evident that this installation is the last word in textile factory practice, on which improvement would be difficult, if not impossible No modern development has been neglected for the production of the best that is possible for this important item in the construction of the Dunlop motor tyre.

The electrical plant, lamps, cables, etc., were supplied by the General Electric Co. Ltd., of Witton, Birmingham, through their local office at Victoria Bridge, Manchester.

## THE BRITISH ENGINEERS' ASSOCIATION.

The fifth annual ordinary general meeting of the British Engineers' Association was held at Caxton Hall, Westminster, London, on Thursday, July 26th, and was attended by a large number of representative members

Textile Mill Electrification.—Fig. 8.

from many parts of the country. In moving the Council's report, balance sheet and income and expenditure account for the year ended December 31st, 1916, which had been issued to all members, the chairman (Mr. Wilfrid Stokes) reviewed the work done by the association during the past year, and dealt with the action which it was proposed to take in future. The new memorandum and articles of association, which had been revised in accordance with the resolution passed at the extraordinary general meeting of the association on July 13th, 1916, had received the sanction of the Courts, and were now operative. Mr. Stokes reminded members that the memorandum and articles had been revised in order to strengthen the relations between manufacturing engineers and those bodies and individuals with whom they are naturally brought into contact in the course of their, business, as set out in the Manchester scheme for the organisation of the British engineering industry. He pointed out that much interest had been shown in the election of the new Council, and for the 30 seats on the Council about 90 members, including retiring members, were nominated in the various districts, a total of 1,369 votes being recorded. At the first meeting of the Council, held the same day, Mr. Wilfrid Stokes was re-elected president, and the Council now stands as follows. President, Mr. Wilfrid Stokes; vice-presidents, Mr. T. O. Callender, Sir John Cowan, Mr. Peter Denny, Mr. Herbert Marshall, Captain L. E. Mather, Mr. J. E. Thornycroft, Mr. Douglas Vickers; members, Mr. Daniel Adamson (J. Adamson and Co.), Mr. H. Alcock (W. T. Glover and Co. Limited), Mr. H. Austin (Austin Motor Company Limited), Mr. Stanley Brotherhood Peter Brotherhood Limited), Sir Edwin Grant Burls, C.S.I. (Vulcan Foundry Limited), Mr. George Cradock (George Cradock and Co. Limited), Mr. Robert Goudie (Loudon Brothers Limited), Mr. John Hemming (F. H. Lloyd and Co. Limited), Dr. G. B. Hunter (Swan, Hunter and Wigham Richardson Limited), Mr. John Hunter (Sir William Arrol and Co. Limited), Mr. A. Jacob (British Aluminium Company Limited), Mr. Christopher James (Joshua Buckton and Co. Limited), Mr. J. R. C. Kearns (H. W. Kearns and Co. Limited), Mr. B. Longbottom (Electromotors Limited), Mr. Hugh Lupton (Hawthorn, Davey and Co. Limited), Mr. C. P. Martin (C. A. Parsons and Co. Limited), Mr. A. E. Owen (Rubery, Owen and Co.), Mr. Henry Steel (Steel, Peech and Tozer Limited), Mr. T. Cuthbert Stewart (Stewart and Lloyds Limited), Mr. H. J. Ward (J. and E. Hall Limited), Mr. J. C. Ward (Edgar Allen and Co. Limited), Mr. A. P. Wood (the Lancashire Dynamo and Motor Company Limited).

## COLONIAL ENGINEERING PROJECTS.

We give below a few particulars, taken from the *Board of Trade Journal*, concerning several colonial engineering projects. Further information concerning these can be obtained from the Department of Commercial Intelligence, 73, Basinghall Street, E.C. 2.

*South Africa.*—H.M. Trade Commissioner in South Africa reports, under date May 15th, that he has recently visited various towns in the eastern portion of the Cape Province, and has been informed that considerable developments are pending in connection with water supply and sanitation in the localities mentioned below. Queenstown has a good water supply, and has recently installed a sewage disposal plant. A large part of the town is now sewered, and domestic installations are replacing the bucket system. King William's Town has ample water, but is deferring outlay on sewerage until after the war. Grahamstown is somewhat unfortunately situated. The town has hitherto depended on certain reservoirs, liberally supplemented by domestic rain-water tanks. The rainfall over the town's catchment area during the last three years has been very short, and if it had not been for rain-water supplies from their own tanks, the position of householders and of educational and other institutions would have been very grave. Of additional catchment areas available, none are really suitable for impounding water, but experts have been called in to advise as to obtaining supplies for the locality. The health authorities at Port Elizabeth have recently called attention to the urgent need for a thorough overhaul of both water supply and sanitary facilities, as in several towns in the district the water supply system combines irrigation of the surrounding lands with the provision of water for domestic and other urban use. At present there is only a bucket sanitary system in use in the locality. Outdshoorn water supply is good, though not sufficient to make a water-borne sewerage system possible. Here also local landowners have a claim for irrigation water. A comprehensive irrigation scheme is in contemplation in an adjacent district and this is likely to lead to extensive modifications of existing arrangements. East London (including the suburb of Cambridge): The municipal authorities have decided that a pumping scheme to obtain additional water from the Buffalo River is the only financially possible means of augmenting the water supply of their district. It is stated that when an efficient water supply has been obtained a water-borne sewerage scheme will follow. According to the report of the city engineer, it is proposed to establish a new pumping station on the Buffalo River, at a point about three miles above the city's present pumping station. The station would be equipped with a modern plant, including a ram pump capable of raising 2,304,000 gallons of water per day of 24 hours. The water would be delivered through a 15-in. cast-iron main, 7,200 ft. long, to a proposed new impounding reservoir, the site of which is regarded as suitable, as, generally speaking, rock has been reached at 4 ft. to 5 ft. below the surface. The capacity of the reservoir when full would be 254,368,940 gallons. As the water from the Buffalo River is often turbid, a settling tank with a capacity of 1,000,000 gallons would be provided. Provision would be made for three filters, to deal with 1,250,000 gallons per day. Two service reservoirs have been provided for in the scheme, each 200 ft. by 110 ft. by 12 ft. deep, the combined capacity of which would be 3,000,000 gallons. A new 12-in. cast-iron main, six miles long, would be required to connect the new reservoir with East London. New 15-in. mains connecting the old pumping station with the new reservoir, and the new station with the old reservoir, would be required in connection with the scheme. Reticulation of new mains for supplying various districts and the wharves at East London is provided for in the scheme. It is suggested that when tenders are called for alternative figures should be obtained for operating the pumping plant by (*a*) steam power, and (*b*) electricity. The cost of the whole of the works comprised in the scheme is estimated at (*a*) with steam-pumping plant, £148,281; and (*b*) with electrically-driven plant, £134,347.

# ENGINEERING PRECAUTIONS IN RADIO INSTALLATIONS.*

By Robert H. Marriott.

In this paper the subject will be considered under four general headings: (1) Wherein dangerous shocks may be received from radio apparatus. (2) Wherein radio apparatus provides a path for currents other than radio currents; (*a*) lighting, (*b*) antennæ coming into contact with lighting or power lines. (3) Wherein radio apparatus provides the current or potential by direct discharge. (4) Wherein radio apparatus provides the current or potential by induction.

1. Injurious shocks may be received from the transmitter circuits. There are, or were, a few cases of dangerous practice along these lines. One was to shunt the operating key so that the transformer secondary was at a fairly high potential when the key was open. Another dangerous method, and probably by far the most dangerous to the life of the operator, was to use alternating-current primary generators which gave an open circuit voltage as high as 500 or 600 volts, and connecting that high voltage circuit through the operating key. Possibly it is reasonably safe to use a generator open circuit voltage as high as 250, but, all things considered, it may be best to bring this voltage down nearer 110, even if efficiency of transformation has to be sacrificed slightly.

2 (*a*). The danger of fire being produced by lightning striking the antenna is apparently less than the danger in ways mentioned under headings 2 (*b*), 3 and 4. Personally, I have never seen lightning strike an antenna, nor have I seen evidence that lightning has struck an antenna. However, I have frequently seen antennæ discharge to ground when lightning apparently struck at some distant point.

2 (*b*). At one time a report was brought in that lightning had struck a radio, burning up the receiving apparatus. On investigation it was found that someone had changed the antenna wires from their former position, and had placed them across and above a 1,200-volt line.

3. The greatest number of fires I have noticed starting from direct discharge of transmitters have been where roof insulators or deck insulators leaked current to the roof or deck, and where the roof or deck was of some combustible material. However, none of these fires have resulted in serious conflagrations, probably because they almost invariably occurred during rain or very damp weather, the dampness or rain serving both to short-circuit the insulator and put out the fire.

Portions of transmitters, such as condenser supports, transformer supports, etc., have frequently been charred to some extent. There is less danger of fire being caused by the apparatus which is mainly in use now because, with the exception of auxiliary apparatus, as used by one company, but now being discontinued, the plain antenna method of connection of the transmitter has been discontinued. The plain antenna connection brings the full spark gap potential to the roof or deck insulator, thereby causing it to break down. A majority of the cases observed where the roof or deck was set on fire were brought about by this type of apparatus.

In the earlier days of radio work a common method of bringing the antenna through the wall of the house was to bring this connection through the middle of a large window pane. This practice was usually fairly satisfactory and not very expensive.

For inside work the writer adopted a general rule of providing surface insulation equal to eight times the sparking distance through air. For example, if the wire used in the circuit would spark to objects at a distance of 1 in. (2·5 cm.) through air, this wire was held away by a porcelain rod 1 in. (2·5 cm.) in diameter and 8 in. (20 cm.) long. Porcelain cleats on series are probably as inexpensive an insulator as may be used for guying small antennas, considering their insulating qualities.

4. For the purpose of this paper the currents which are set up in conductors not connected to antenna, but due to the radio frequency currents in that antenna, will be referred to as "induced radio currents," and the transference of energy from the antenna to other unconnected circuits will be referred to as "by radio induction."

The greatest damages from fire which are known to me have occurred where the transmitters were not connected with the point which took fire. In these cases the transmitter caused high potentials in conductors which were more or less distant from the transmitter; that is, these conductors acted somewhat as receiving antennæ, and were close enough to rise to a high potential. Where these conductors consisted of telephone circuits the lightning arresters provided on the telephone circuits usually short-circuited to ground by the fusing of the metal in the arrester.

This grounding of the telephone circuits usually rendered the telephone circuit inoperative. In the cases of lighting and power circuits carrying direct current or alternating current, such as 60-cycle alternating current, the high potential radio frequency alternating current induced on these lines was apparently superimposed on the direct current or audio frequency alternating current. The radio frequency current produced on these lines was frequently of very high voltage comparatively while the other current (direct or audio frequency) on the lines was of comparatively high amperage. When the radio potential occurred at a point within striking distance of an object at opposite potential it apparently discharged and carried the direct current or audio frequency current over after it. In many cases the arcs so formed held until the terminals of the arc or part of the circuit burned away. Power transformers, lighting transformers, motors, generators, relays, magnetos, wattmeters, ammeters, voltmeters, lamp sockets, rosettes, etc., burned out or were rendered inoperative apparently from this cause. On a number of occasions lamp cord carrying 110-volt direct current or 60 cycle alternating current, has been short-circuited, and on one occasion an 8 ft. (2·4 metres) drop cord disappeared in flame and a near-by motor was short-circuited. On other occasions lamp cord lying against wooden moulding short-circuited and burned, setting fire to the wooden moulding. On these occasions, people were near by and put the fire out before it reached any material magnitude.

On one occasion receiving and transmitting apparatus were located very near to the transmitter. The result was that motor and generator windings, relay windings, reactance coil windings, etc., were repeatedly short-circuited. This was stopped by providing radio frequency paths through condensers across points which developed high radio frequency potential; also, by placing the wiring in grounded iron conduit, and the short sections of wiring of the switchboard in grounded lead-covered wires; and finally, by placing a grounded wire netting screen between

* Abstract of a paper read before the Institute of Radio Engineers, New York.

the transmitter and the apparatus. All of these expedients were put into effect before noticeable potentials were avoided.

Radio-frequency currents possibly in some cases have been superimposed on high-tension circuits of the transformers, at least across portions of the secondary of such transformers. It is not quite so easy to conceive how this radio frequency potential may occur in the secondary where so many turns of fine wire are used.* However, when transformers were placed in certain relation and near radio frequency circuits they broke down sometimes between sections and sometimes from secondary to primary and similar transformers when substituted and moved further away or turned at an angle did not break down.

*(To be continued.)*

## RADIATION ERROR IN MEASURING TEMPERATURE OF GASES.†

By Henry Kreisinger and J. F. Barkley.

Of the errors entering into the determination of the average temperature of a stream of hot gases surrounded by colder or hotter surfaces, the radiation error is the most serious one and the most difficult to correct. Ordinary temperature measurements made with commercial devices under such conditions are from 5 to 25 per cent in error. If the surrounding surfaces are cooler than the gases, the temperatures indicated by the measuring instrument will be too low; or if the surrounding surfaces are hotter, as is the case in regenerating furnaces, they will be too high. The object of this paper is to show primarily how large the radiation error may become under certain conditions of temperature measurements, and that judgment must be used in interpreting the accuracy and the value of temperature readings.

The radiation error is due to the fact that, to a large extent, gases are permeable to radiation. When a temperature-measuring instrument is immersed in a stream of hot gases surrounded by cooler surfaces, it absorbs heat from the gases by convection and its temperature rises. As soon as its temperature exceeds that of the surrounding surfaces, heat passes by radiation from the instrument to these surfaces through the intervening gases. Thus the instrument receives heat from the hot gases by convection, and gives off heat by radiation to the surrounding colder surfaces. The temperature of the instrument continues to rise with a decreasing rate until the quantity of heat it gives off is equal to the quantity of heat it receives; the temperature then remains constant. Under these equilibrium conditions the temperature of the instrument is between that of the stream of gases and that of the surrounding surfaces; in other words, it is lower than the temperature of the gases which it is intended to measure.

In a similar way, when the instrument is inserted in a stream of gases surrounded by surfaces hotter than the gases, and when equilibrium conditions obtain, the temperature of the instrument is somewhere between that of the surrounding surfaces and that of the stream of gases; in other words, it is higher than the temperature of the gases which the instrument is supposed to measure. The difference between the temperature of the gases and that indicated by the instrument is the radiation error.

The magnitude of the radiation error depends on (1) the size of the part of the instrument exposed to the gases and the radiation, and (2) the difference between the temperature of the gases and the temperature of the surrounding surfaces. The smaller the exposed part of the measuring instrument, the smaller the radiation error; also, the smaller the difference between the temperature of gases and

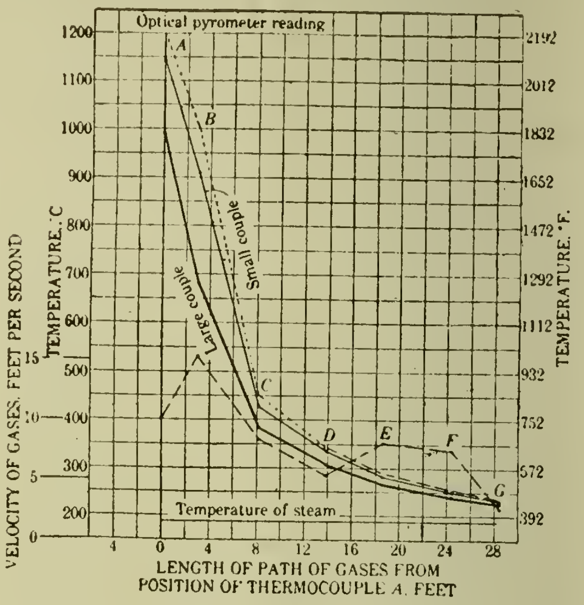



Fig. 1.

the temperature of the surrounding surfaces, the smaller the radiation error. In the measurement of the temperature of gases only the first-named factor can be controlled. The second factor is fixed by the kind of apparatus and its operation.

Of the instruments used in the measurement of temperature of gases the thermocouple lends itself the best to the reduction of its size. It can be made so small that

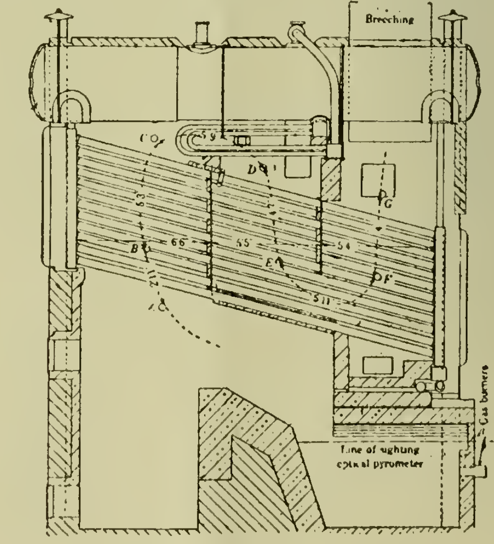



Fig. 2.

the radiation error is negligible for practical purposes. The correct temperature would be indicated only by a thermocouple having an exposed hot junction made of wires of zero diameter, which, of course, is a physical impossibility.

The effect of the size of thermocouples is shown in Fig. 1, which gives two sets of temperature measurements of the

* A probable explanation is the distributed capacity of the secondary windings and consequent internal resonance effects with breakdown.

† Abstract of paper read before the American Society of Mechanical Engineers.

gases passing through a Babcock Wilcox boiler fixed with natural gas. One of these sets of measurements was taken with thermocouples having the hot junction made of wires 0·008 in. diameter, and the other made of tubes about 0·500 in. diameter. This large couple is about the size of commercial instruments used for such purposes. Several thermocouples of each size were made and clamped together in pairs, each pair containing a large couple and a small couple, with their hot junctions about 1½ in. apart. These pairs were placed at different points along the path of gases, indicated by the small circles and designated by the letters A, B, C, D, E, F, and G in Fig. 2. All the couples were connected to a central switch and read in rapid succession with a portable potentiometer. While the readings were taken the furnace conditions were kept uniform, which was a comparatively easy task with the gas firing.

In Fig. 1 the abscissæ are the approximate lengths of the paths of gases, measured from the position of the first pair of couples A. The full heavy curve connects the readings obtained with the large couples, and the full light curve the readings obtained with the small couple. The dotted curve above the full curves gives the probable true temperature of the gases, obtained by extrapolation from later curves. The curve near the bottom of the figure (drawn with dashes) gives the approximate velocity of the gases computed from the volume of gas burned, the chemical analysis of the products of combustion, and the true temperature of the gases. The small black circle at the upper left-hand corner gives the furnace temperature as measured with the Wanner optical pyrometer sighted through one of the gas burners, as shown in Fig. 2.

The two full curves of Fig. 1 indicate that the small couples consistently showed temperatures considerably higher than the large couples, although the small couples themselves read somewhat too low. The difference between the readings of the two couples is nearly proportional to the difference between the true temperature of the gases and the temperature of the surrounding boiler surfaces, which was about 50 deg. higher than the temperature of steam in the boiler. The large couple at B shows a radiation error of about 575 deg. Fah., whereas the small couple at the same place indicates an error of only 150 deg. Fah.

## INTERNAL-COMBUSTION MARINE ENGINES IN JAPAN.

The use of internal-combustion marine motors in Japan, up to the present time, has been confined chiefly to engines suitable for passenger launches and fishing boats, to heavy-duty, slow-speed, moderate-power engines, preferably built to burn kerosene or producer gas. Small pleasure launches, using high-speed petrol engines of 3 H.P. to 10 H.P., are found in Tokyo and the various ports.

The Japanese were quick to realise the value of the cheap transportation afforded by the use of launches on the rivers and canals of the larger cities. In Tokyo, launches with two or three trailers maintain regular service up to the Sumida River and certain canals. They are separated by motors burning producer gas generated from coke. In a similar service in Yokohama the launches utilise semi-Diesel, kerosene-burning engines. There are also several launches plying between the mainland and the smaller islands of the Inland Sea. The number of passenger launches, however, is relatively small, and, in view of the rapid development in street railway transportation in the cities, it is not likely that the number will be increased to any extent in the future. By far the greatest use of marine engines is in the fishing trade. As a rule, the engines are not used on the fishing boats themselves, but on vessels which visit the mall villages in certain districts, collect the fish from the local fishermen, and take them to the cities. These vessels are of both Japanese and foreign types, but the predominant type is a round-bottom craft, 40 ft. or 50 ft. long, with a beam of 12 ft. to 15 ft., and a draught of about 3 ft. Some are schooner-rigged, but they usually rely upon their engines.

It is difficult, writes the United States Vice-Consul at Kobé, to describe any one boat as a standard, but in the usual type the engines used are slow-speed, heavy-duty motors, two-cycle, with one or two cylinders, and from 20 to 50 B.H.P. These motors are usually of European or Japanese make, and burn kerosene or producer gas. The older models have heated carburettors for the purpose of vaporising the kerosene and are fired by electricity; but the later types use the semi-Diesel system of a hot bulb and fuel injection for vaporisation and ignition. The engines usually swing three-blade propellers of 24 in. to 28 in. diameter at the rate of about 400 revolutions per minute, and give the vessels a speed of seven or eight knots an hour.

As many of the bays and harbours of the Japanese coast are very shallow, these fish-collecting boats are often equipped with propellers which may be raised or lowered at will, by means of a telescopic rear strut and a universal joint on the propeller shaft just aft the stuffing-box on the exterior of the hull. The tunnel-stern construction for shallow water, with the propeller operating within an enclosed tunnel has not yet been introduced into Japan. Large-size Diesel engines have not yet been adopted to any great extent. The innumerable small islands that make up a large part of the Japanese Empire offer an extensive field for small trading vessels. This field is at present occupied by small steamers and by schooners of about 500 tons dead-weight, which depend upon their sails alone for motive power. These schooners could be advantageously equipped with Diesel engines for auxiliary power, but this has not yet been done on account of the limited capital upon which the owners of the vessels operate.

Several ironworking firms have recently undertaken the manufacture of marine engines in Japan, one of the most important being the Ikegai Iron Works of Tokyo. Its engines are of the two-cycle semi-Diesel type, and range from 3 H.P. to 50 H.P. in stock sizes. Larger motors are built to order. Below 30 H.P. the engines are single cylinder; above that, double. The engines have high compression and ignition is effected by injecting the fuel, in the form of a spray, against a hot bulb in the cylinder head. Although the system is the same as that used in other countries in engines operating on crude oil, the Ikegai engines are usually run on kerosene or other light oils only.

The principal manufacturer of producer-gas marine engines is the Hatsu-do-ki Seizo Kabushiki Kaisha (Internal-Combustion Engine Manufacturing Co.) of Osaka. The engines produced by this firm are of the four-cycle type from 20 H.P. to 50 H.P., and of one and two cylinders. These engines are not kept in stock, but are manufactured as the demand arises. About 50 per year are produced. No small, high-speed petrol motors are manufactured in Japan.

Up to the present time engines of German, Swedish,

and English makes have dominated the market; but during recent years Japanese-made engines have been gradually superseding the European motors.

Japan, with its innumerable bays, rivers, lakes, and canals, would seem to be an ideal place for small pleasure launches and moderate-size cruisers; but in reality the number of such boats is very small. The reasons are: (1) The fact that the Japanese have not yet adopted boating as a sport; (2) the high price of motors; and (3) the high price of petrol.

## TAR OIL FUEL AND DIESEL ENGINES.

*(Continued from page 414.)*

I PROPOSE now to compare the analyses "A" to "E 2" in Table I. with these specifications. To the best of my knowledge the samples tested were derived from English sources. Speaking generally, the tar oils supplied agree in substance fairly closely with the specifications. I must point out that it is desirable, at the present moment, not to draw a specification for tar oil too tightly. So far as the demand for these oils in connection with Diesel engines is concerned, it is a new one in this country. Tar oils for our purpose are not yet standardised, and it is too early as yet to draw hard and fast lines. The products we are obtaining are, in general, giving satisfactory results. The specific gravities vary a good deal among themselves, but they all lie within the limits mentioned by Mr. Batho. "E 1" is 3·1 per cent heavier than "D," the least heavy of the series. I have not heard that any difficulties have arisen that are attributed to specific gravity. The flash points have been ascertained in only three instances; they are taken at different temperatures, and are perhaps high, especially that of "C."

Samples "C" and "C 2" are in excess of the others in respect of water—in fact, a great deal in excess. E 2 is so extraordinarily high that I think some special circumstance must account for the figure, 11 per cent. I understand that the water content is a difficult one to determine, chiefly because of the peculiar property of water to collect in pockets in oil. Hence a sample may not be representative of the bulk, and *vice versa*. Further, the oil enters into ebullition at 212 deg. Fah. Tests of water content must therefore be accepted with caution. Owing to the high specific gravity of the tar oil, water is not so troublesome in ordinary engine operation as it rises to the top of the service tanks. With petroleum residual oil the reverse is the case, and water occasionally will stop an engine if the attendant is not careful. That water is a useless addition to a fuel oil requires no argument.

The sulphur contents in these samples are all good, the "C" samples showing the greatest proportion. Otherwise the sulphur percentages are within the specified limits. The influence of sulphur in Diesel engines was very fully described by Dr. E. Graeffe, of Dresden, and reported at an association meeting in 1915. Dr. Graeffe treated the matter exhaustively, as will be seen by members if they care to look up his communication. Nevertheless, it is desirable to keep the sulphur content low.

Except for "C 1" and "E 1" the ash contents of the samples are tolerably close to the M.A.N. limit, but all are well below the maximum quoted by Mr. Batho.

The coke residue of the four samples are near to the specified limits for "B" and "E 1," but appear to be rather excessive for "C 1" and "C 2." This item must be carefully studied. I have seen tests which indicated a coke content as high as 26 per cent. Such an oil would be unsuitable for use in a Diesel engine.

As suggested by Mr. Day the calorific values agree fairly closely with one another and with the specifications. The *lower* calorific value is, of course, the important one for our consideration. In the case of "D" the lower value is approximately 16,430 B.T.U.'s per lb. Below a value of about 15,800 the oil is unsuitable for use in Diesel engines.

Only in the case of "C 1" and "C 2" have the constituents insoluble in Xylol been obtained. This is a pity, for the proportion of these insoluble substances is an important matter. It is essential to reduce the amount of suspended solids in the oil to an absolute minimum, for they form nuclei for the formation of deposits which carbonise and give rise to difficulties in working an engine. The figure ascertained for the "C" samples is fair—much lower than the percentage put forward as permissible by Mr. Day. They are, however, very excessive when compared with the M.A.N. Co.'s requirements. The "C 1" and "C 2" samples differ in themselves by 85·4 per cent. Evidently, the German company insists on a nearly perfect exclusion of insolubles, in which requirement it must be conceded they are on firm ground. (Many of us, no doubt, do not know what "Xylol" is; it is described as dimethyl benzol, and has the chemical formula $C_8H_{10}$; its boiling point is 139 deg.) The percentage of distillation below 610 deg. Fah. has been determined only for "A," "C 1," and "C 2," and the samples conform fairly well with specification No. 2.

The carbon, hydrogen, oxygen, and nitrogen percentages have been determined in one instance only, "E 1"; these particulars are of interest in connection with the heating value of an oil; they are necessary when it is required to work out a heat balance-sheet from engine trial results. Mr. Harold Moore published some useful analyses in a paper read by him on February 26th, 1916, before the Manchester Association of Engineers; the tables well repay study. It is a somewhat remarkable fact that the results shown by the test of the sample "E 1" are in every respect identical with Mr. Moore's figures for a horizontal retort tar oil. If the origin of the samples should be the same the accuracy of the distillation is remarkable. "E 2" represents a second evaluation of the calorific value of an oil obtained from the same source. It will be seen that the figures obtained differ considerably from those stated under "E 1"; the water content is very excessive. Whether this result is due to the "pocketing" of water in the sample, and is therefore not truly representative of the bulk, I am unable to say, but the purchaser has not intimated to me that worse results were obtained in the use of the later oil than he found in the case of the earlier deliveries.

It is a matter for regret that none of the tests contain the determination of the setting point, for it is intimately concerned with the phenomenon of "crystallisation."

The M.A.N. specification (1) requires the oil to remain liquid at a temperature of 46·5 deg. Fah. when it is undisturbed for a period of half an hour, and to be fully liquid at 61 deg. Fah. Mr. Day's specification concurs. Those of us who have been using tar oils for the first time during a particularly cold winter have learned by experience that this desideratum is not merely a chemist's fad. At a temperature below 45 deg. Fah. crystallisation is heavy. In one instance I found fully 30 per cent of the contents of a tank of oil (out of doors), containing 11 tons, to be extremely thick. It could not be pumped at

all. Heating a gallon drawn out in a pail dissolved the crystals, but to heat the whole tank was impracticable. Finally, the difficulty was overcome by violently agitating the bulk, when the oil became fluid. This method was adopted throughout the winter as occasion required; it cost nothing, and was quite successful. I do not know definitely if crystallisation is accentuated by an excessive proportion of naphthalene in the oil. All tar oils, I am informed, contain naphthalene in greater or less degree. It appears to an engineer obvious that the formation of naphthalene crystals on cooling may contribute largely to the crystallisation of the tar oil by providing a large number of nuclei about which films of oil concentrate until a semi-solid condition is attained. I should say that this theory is pure speculation on my part, for I am in no sense a chemist, and I have had no opportunity of taking up the naphthalene question seriously with a qualified man. Naphthalene itself has a high calorific value, and has been used successfully in an internal-combustion engine as the sole fuel. Moreover, a creosote oil containing a high percentage of naphthalene when mixed with a very viscous mineral oil (residual) has a lower viscosity than either of its constituents. I am indebted to Mr. G. Nevill Huntly, B.Sc., F.I.C., for this interesting piece of information. Naphthalene then, whatever its disadvantageous properties may be, has good and useful characteristics. From our experience up to the present, one fact at any rate emerges, *i.e.*, that tar oil is better stored under cover in a moderately high temperature than in the open. I have, fortunately, not been troubled with the formation of crystals in railway tank wagons. Possibly the heavy vibration in transit is sufficient to maintain the oil in a continuous state of agitation. There is obviously a great deal to learn about tar oils for our purpose, and in this we can hope for the co-operation of the skilled analytical chemist. The training and experience of the engineer are not such as to fit him, as a general rule, for the solution of physical problems such as are met with in examining oils. The engineer (in his own opinion at least) rules the world nowadays; but I am not sure that the analytical chemist does not actually sit in the heart of things.

*(To be continued.)*

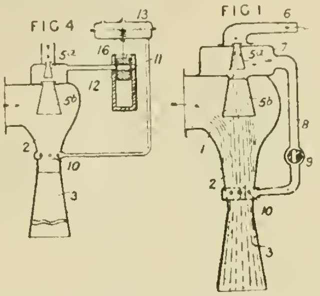
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

## ABSTRACTS OF SPECIFICATIONS.

### EJECTORS.

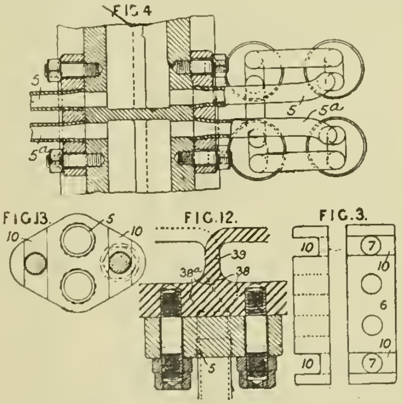
107,047. A E. L. SCANES, Strathfield, Harboro' Road, Ashton-on-Mersey, Cheshire.—June 10th, 1916.—Relates more especially to steam ejectors for exhausting air and non-condensable vapours from a steam-condenser. In such apparatus, if required to produce a high degree of vacuum, the proportions of the parts are such that, on starting, pressure falls in the expansion nozzle below that in the body of the ejector, with consequent loss by shock and eddies resulting in delayed starting. To remedy this, the expansion of the inducing-fluid is reduced below normal until pressures corresponding to the usual compression-ratio have been established, by means of the admission of additional elastic fluid at intermediate points upon the expansion nozzle, at a pressure greater than that to which the inducing fluid normally expands at such points. According to one arrangement, steam or other inducing-fluid entering by a pipe 6, Fig. 1, passes through a divided expansion nozzle, 5*a*, 5*b*, before entering the suction chamber 1, mixing-cone 2, and diffuser 3, steam being drawn, from a point 10 of the mixing-cone having the desired pressure, through a pipe 8 and chamber 7 to the gap in the expansion nozzle so long as the pressure at the point 10 remains above that produced by expansion in the first part of the expansion nozzle, which thus acts at starting as a small ejector. If the pressure at the selected point 10 be normally slightly higher than this, regulation by a throttle valve 9 becomes possible. Ejectors having several expansion nozzles in parallel may be provided with a common chamber 7 connected with the mixing-cone; the expansion nozzles, also, may in either case be divided into more than two parts, each division having its closed chamber and connection with the mixing cone. In other arrangements, the connection may




be made to other sources of fluid-pressure, *e.g.*, the atmosphere. Fig. 4 shows such a modification, wherein air entering at a port 11 is regulated by an automatic throttling valve 12 positioned by means of a differential-pressure diaphragm 13 and spring 16 according to the difference between atmospheric pressure and that existing at the selected point 10 in the mixing-cone.

### STEAM SUPERHEATERS.

107,023.—J. G. ROBINSON, "Mere Bank," Fairfield, Manchester, and SUPERHEATER CORPORATION, 9, Bridge Street, Westminster.—March 15th, 1916.—The ends of a U-tube element are fixed in a flange block 6, Fig. 3, having holes 7 in its ends to receive the screwed studs or the like projecting from the bottom or wall of the header, channels 10 being cut across the block at the inner ends of the holes so as to lessen the necessary bending of the tube-ends when placing the block over or removing it from its studs. To facilitate further the connection and disconnection of an element, the tube-ends 5, 5*a*, Fig. 4, inside the smoke-tubes

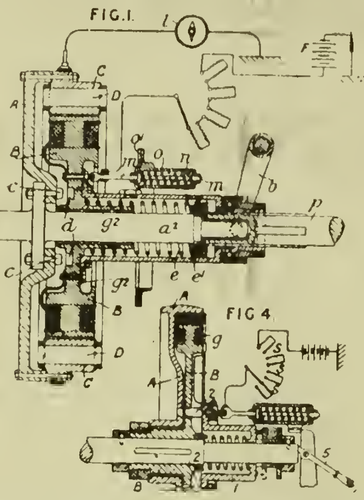



are bent, so that for a portion of their lengths they lie close to the walls of the smoke-tubes towards the header. The holes in which the tube-ends are fixed in a flange block may be arranged diagonally, and the holes receiving the screwed studs may be arranged diagonally in the opposite direction. The tube-holes 5, Figs. 12 and 13, in a flange block are arranged transversely of the block, and communicate with holes 38, 38*a* in the header wall opening at their inner ends on opposite sides of a partition 39. Adjacent elements may have a common flange block. The loops at the header ends of the elements may project for a considerable distance into the smoke-box so as to enable the ends of the elements to be bent downwards within the loops.

### POWER TRANSMISSION CLUTCHES.

107,049. J. ROELS, 19, Northfield Avenue, North Shore, Blackpool. June 12th, 1916. An electro-magnetic clutch comprising a squirrel-cage member and a salient pole member is provided with means for withdrawing axially the one member from the other and for locking the two members together when rotating at the same speed. The driven member B formed with salient poles excited from a battery F is connected to the driven shaft *p* by a sleeve *e*1 enclosing a spring *e*. By depressing the pedal *b* the member B can be withdrawn from the member A against the spring *e*. In addition to the squirrel-cage winding D on the member A, a second winding is provided connected to a current meter *l* for indicating when the two members are rotating at the same speed. When this occurs, the two members are locked together by tapering recesses *d* engaging with corresponding projections *c*. The brush bearing on the collecting-ring *g*2 is carried by a holder *m* mounted in a casing *o*. A spring *n* maintains the brush in contact with the collecting-ring *g*2 until the two members A, B are locked together, a member on the holder *m* engaging with the end of the casing *o* and so limiting the further movement of the holder. The member B can be braked by withdrawing it into engagement with a flange *o*1 on the casing *o*. The clutch shown in Fig. 1 is particularly adapted for use on motor-cars, the prime mover being

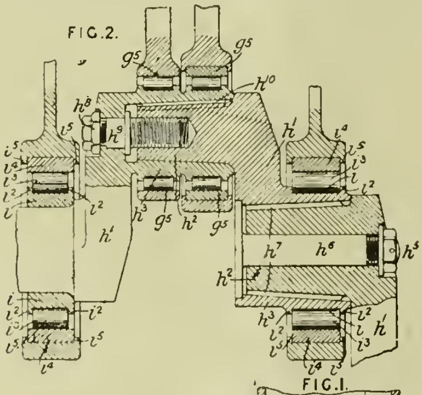
connected to the member A through the shaft $a2$. In a modification adapted for the transmission of power to machinery, the member A, Fig. 4, is driven by belt or toothed gearing and the clutching effect is varied by means of resistances $s$ in the circuit

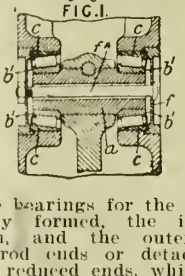



of the electro-magnets $g$. The two members are locked together by tapered studs 2 passing through holes in the member B and engaging in tapered holes in the member A, the studs 2 being carried by a sleeve 1 operated by a handle 5.

### CRANKSHAFTS, BEARINGS.

107,052.—T. L. R. D'ORVILLE, formerly 241, Addison Way, Golders Green, London, now Cross Deep Lodge, Twickenham, Middlesex.—June 13th, 1916.—In an aeronautical or other internal-combustion engine, the small and big ends of connecting-rods and the crankshaft bearings are provided with anti-friction rollers, and a built-up crankshaft is employed. The latter, as shown in Fig. 2, consists of **Z** sections fitting into one another, each section consisting of a web $h1$, which may be milled to **H** section, and a conical pin $h2$, and an internally conical sleeve $h3$. The engaging parts which form the crank-pins are drawn together by screws and nuts $h9$, $h8$ and are locked by keys $h10$, while the portions forming the crankshaft journals are formed with engaging ribs and recesses $h7$, and are drawn together by bolts and nuts $h6$, $h5$. The inner races $i$ for the rollers $i3$ of the crankshaft bearings may be formed in the crankshaft, or may be separate, and formed with retaining flanges $i2$. The outer races $i4$ are secured in the crank-casing by retaining flanges $i5$. One pair of bearings may




be fitted with tapered rollers. The bearings for the big ends of the connecting-rods are similarly formed, the inner races being formed in the crank-pin, and the outer races $g5$ either formed in the connecting-rod ends or detached. The gudgeon $a$, Fig. 1, is formed with reduced ends, which are supported in roller bearings inclined either outwards, as shown, or towards the centre. The rollers also are formed tapered and are grooved at one end to receive retaining flanges $b1$ on the inner races, which may be formed in the gudgeon or separate as shown. The inner races may be adjustable by nuts screwing into the gudgeon, or, as shown, the outer races $c$ may be adjustable by cups $f$ screwed into the piston or drawn together by a bolt $f^*$ passing through the hollow gudgeon. The spaces enclosed by the cups $f$ may be supplied with oil for lubricating and cooling.

# INDEX TO ADVERTISERS.



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— THE —
# Industrial Engineer.

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## The Industrial Engineer.

*A PRACTICAL MAGAZINE FOR ENGINEERS AND POWER USERS.*

Published twice monthly, on the 8th and 22nd days, respectively.

*All communications intended for insertion in the* Industrial Engineer, *or relating to Editorial matters, should be sent addressed to " The Editor," at our Office,* 121, *DEANSGATE, MANCHESTER, and must be accompanied by the name and address of the writer. Anonymous letters will not be noticed. We cannot undertake to return manuscripts or drawings, and correspondents are warned to keep copies.*

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CONTENTS.



# EDITORIAL.

## SCIENTIFIC AND INDUSTRIAL RESEARCH.

If there is one thing more than another which the war has accomplished in the domains of science and industry it is the awakening of the British people to the weaknesses which existed in many branches of our industry, and the necessity which thereby arose of exerting ourselves to remedy the defects. The war found us short of many things upon which we had to depend in peace times on enemy resources. The number of these things was found to be enormously large. We had drifted into an acceptance of their use as easily as we individually drift into wearing a new suit of clothes. It is interesting and fascinating at first in its very newness, but having settled down to regular wear, we took it as a matter of course, and then ordered again from the same place. We accepted German manufactures in this way as a regular thing, and apparently hardly asked ourselves whether we could do the same thing for ourselves. Probably we relied upon the doctrine of the exchange of goods as between one country and another as being the be all and end all in trade. The war has emphasised the fact that we can struggle along very nicely without Germany's aid, even if we may be eating a bit of our own tail. But the great outstanding fact is that when we really make up our minds we can accomplish anything we have a desire to carry out. We have been forced by circumstances not only to make up our minds but to use them in actual accomplishment. In the making up of our minds we have seen the folly of our pre-war supineness and hence the largely-expressed desire to increase our scientific knowledge by way of research. Fortunately, the Government of the day was sufficiently impressed with the importance of the matter, firstly, as regards the more efficient conduct of the war which would thereby accrue, and, secondly, by the necessity of holding our own in industry after the war, with the possibility of extending our hold to other matters which had previously gone by default into the hands of our competitors. They thus set up the Council for Scientific and Industrial Research, and ear-marked £1,000,000 to assist the researchers. It was a most wise move, and although this body has been in existence for only two years—and this in the most anxious period of the war—it has accomplished great things and put other matters in train for getting even greater results.

The department has just issued its second annual report. This indicates that there are three ways of organising industrial research. The simplest is the case where a single firm can work out a problem and itself fully exploit the results. In most cases, however, problems of industrial research will concern many firms—sometimes many industries; they will require the expenditure of large sums of money and the co-operation of many workers for long periods of time. But if successful, the results will be of immense value.

Most individual firms cannot undertake this long and costly process. Yet, why should the State pay for the whole cost of winning new knowledge which will be valuable to business men? It is hoped that the way out of this dilemma will be found by the establishment of "Trade Research Associations," to be constituted as needed for each industry or group of industries on which are to be represented, when possible, capital, management, science, and labour, and which are to be aided out of the million grant to be administered by the department for the express purpose of establishing such research Associations. One Association is just about to be constituted for the cotton industry, others are being brought

into existence for the wool, flax, shale oil, and photographic industries.

There are also many cases where the problem is so complex or else so immediately concerns the consumer rather than the producer that co-operation between manufacturing firms is not possible. This is obviously the case with fuel. Hence the establishment of the Fuel Research Board which, under the direction of a distinguished man of science, Sir George Beilby, will itself conduct research. So, too, with the problems of fire-resisting materials and the determination of standards and constants. All this is direct work for the whole community acting through its special organ of research. It is interesting in this connection that the Royal Society has recently negotiated with the department the handing over of the financial responsibility for the conduct of the National Physical Laboratory, where investigations of national importance are constantly going on.

The main lines of policy of the new department are being slowly worked out. But it is also not neglecting immediately pressing problems. In glass, for instance, a great deal has been already done—three completely new kinds of optical glass have been discovered by Professor Jackson. A research on light alloys (aluminium, zinc, copper) will be of the utmost importance for the future of aeronautics. A new hard porcelain from purely British materials has already been produced. Researches into the recovery of tin are expected to save the Cornish tin industry £30,000 a year. A large number of other researches are being aided or carried out by the department.

The universities will take their place in the new social tissue whose pattern is now being woven. At a considerable number researches aided or initiated by the department are now going on. At the universities, too, the future research workers receive their training; and 36 (who would otherwise have drifted into immediately remunerative work) were aided by grants from the department in 1916–17.

The report ends by noting the altered attitude of manufacturers and men of business towards the claims of research and education, and reiterates the conviction that a sure advance in industrial science can only be made when the field of work is adequately surveyed beforehand, and an organised plan of attack worked out.

# Publications.

## ELECTRIC MOTORS.

DESCRIPTIONS or specifications of machinery issued by the maker are always interesting reading. One maker emphasises the importance of one particular feature of construction, while another will almost ignore that particular part and specially select another for eulogistic description. What the user wants is a plain, straightforward specification, which will concisely give him the information he seeks, namely, the method and material of construction. In a pamphlet issued by Messrs. T. W. Broadbent Ltd., Victoria Electrical Works, Huddersfield, describing their R type motors, the user will find such a description. The details are in the main similar to those to be found in a collection of motor catalogues, but special features are referred to without undue emphasis. In fact, this is quite a good example of advertising matter relative to what, from the description, appears to be a thoroughly workmanlike type of electrical motor.

## MOTORS AND GENERATORS. Care and Repair.

MAKERS often ignore one very important matter in relation to their dealings with customers. They do not give sufficient information in respect of installation, subsequent running, and upkeep of the machines sold. In many instances this is no doubt unnecessary, but in our experience of many different types of machinery we have been led to the conclusion that the more specialised information available for users the better are the subsequent results. We have been directed to these thoughts by a perusal of a pamphlet issued by The British Westinghouse Electric and Manufacturing Co. Ltd., Trafford Park, Manchester, on "Motors and Generators in Industrial Service, their Installation, Operation, Care and Repair." The information given in this pamphlet is excellent, and if carefully studied or kept for reference, should prove invaluable to users. The advice is practical, and puzzled users will no doubt be materially helped when, for example, sparking at the commutator takes place. Reference to the pamphlet will no doubt reveal one of the several causes which may be responsible for this, and the remedy is given. Quite a useful little publication.

## THE "CANTIE" FUSE GEAR.

DETAILS of the "Cantie" Fuse Gear is interesting reading. Made by the "Cantie" Switch Co. Ltd., 67, Mount Street, Nottingham, the methods adopted are somewhat different to those obtaining in other forms of fuses. Starting off with the endorsed statement that long fuses waste current, it is shown that the "Cantie" fuse of 50 ampere capacity has a fuse length of only 2 inches. In designing this fuse the chief aim has been to produce a sound mechanical result, every part being made to stand rough usage. Emphasis is laid on the fact that there is nothing complicated, and every part is easily accessible. This circular is forceful, and presses home its points excellently.

## HENLEY SERVICE CUT-OUTS.

AN ingenious form of advertising is by means of adhesive stamps. When the design is bold and pronounced the constant use of the stamp will undoubtedly impress people. Such a useful stamp advertisement is the Henley Service Cut-Outs, issued by Messrs. W. T. Henley's Telegraph Works Co. Ltd., Blomfield Street, London Wall, London. All the simple elements of an appealing advertisement are present. Another neat piece of advertising matter is a folder issued by the same company, which deals solely with switch and fuse sets. Neatly printed and designed, it gives a deal of information in a small space.

## MOTORS FOR PORTABLE DRILLING MACHINES.

Sometimes it is a useful practice to print a series of leaflets giving details of the same machine on each but as employed in a particular piece of work. This is particular as opposed to general advertising. Then, again, it is possible that a particular form of machine—a driving motor—for example can be applied to different tools. In principle the motor remains the same, but its application is different, and it is this application which must be brought home to individual users. The Light Electric Motor Co., of Baltic Street, Dundee, have issued a series of leaflets illustrating and describing the application of their form of motor to portable drilling machines, electric grinder for various forms of grinding, pumps, and polishing machines. By so issuing the matter any particular user will receive only such information as is of interest to him.

UTILISATION OF HYDRO-ELECTRIC POWER IN SMELTING WORKS: NEW SMELTING WORKS AT PORJUS FALLS, SWEDEN.—According to the German newspaper the *Rheinisch-Westfalische Zeitung* of 3rd August, a new iron smelting works has been built and has commenced operations at the Porjus Falls, near the largest electric power station in Sweden, from which power is obtained. The first furnace in operation produces eight tons daily; this will be raised to twenty tons with the opening of a second furnace for iron pyrites. A third furnace will produce chrome-iron and other alloys. This, remarks the *Zeitung*, is the first step in the treatment of North Swedish ore on the spot; it is added that the Swedish Government has lately been making efforts to encourage the utilisation of hydro-electric power in ironworks.

## ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAFTSMEN—STRETFORD DISTRICT.

A meeting of members of the above District is to be held in the Church Institute, Stretford, at 7-30 p.m., on the 17th inst. Speakers: Mr. Rostron, Chairman, and Mr. Jolley, Hon. Sec. of the Manchester Branch.

E. P. MORLEY, *Hon. Sec., Stretford.*

## INDUSTRIAL MOTOR ENGINEERING.

By R. Douglas-Vickers.

It is not, I think, too much to say that in the ten years before the war British automobile and traction engines far outstripped those of other countries in the matter of providing a cheap and efficient form of road transport for all sections of the community. In particular, they excelled in the provision of heavy haulage motors, a fact which I am sure will be fully borne out by many

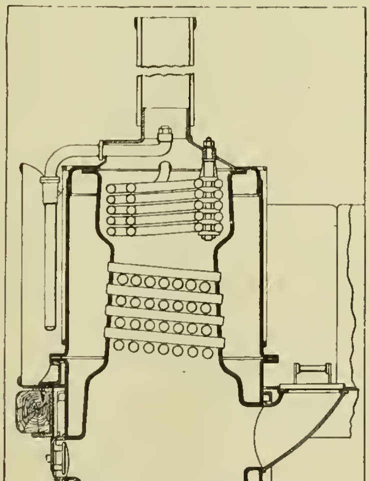
View of the vertical water-tube boiler showing the shute for firing.

industrial engineers. The commercial community were coming more and more to appreciate the value from the economic point of view of the heavy motor—a self-propelled road vehicle which the legislature has determined is one that exceeds two tons in weight unladen. But rapid as the progress was, and great as was the appreciation accorded to this form of conveyance, these were mild in comparison with what has taken place during the past three years. War has done more to make motor transport universal than the peaceful developments of a decade. Many thousands of vehicles are now in use where other methods formerly held sway, and it is safe to assume that this branch of engineering will no longer be outside the ken of the works engineer, the factory chief, or the proprietors of big commercial and manufacturing undertakings. I propose in these articles to deal with the most modern motor truck chassis now on the market—whether of the internal-combustion engine type or the steam engine—and note the most conspicuous features of each.

### I.—The Atkinson Steam Wagon.

The machine that I propose dealing with on this occasion is the Atkinson 6-ton steam wagon, built by Messrs. Atkinson and Co., of Kendal Street, Preston, Lancashire, one of the most interesting of its class on the market. It has a note of distinction in that it has been designed to run on solid rubber tyres exclusively. The boiler is of the vertical water-tube type, with a large horizontal undertype of engine of the double-acting slow-running design. From this the power is taken to a live axle by chain driven from a sprocket on the crankshaft. No gearing of any kind is interposed between these two points. The engine, which is non-compound, has two cylinders, the dimensions of each being $6\frac{3}{4}$ in. bore by 10 in. stroke. The working boiler pressure is 250 lbs. per square inch.

In various respects the design of this vehicle resembles another popular British outfit of which Messrs. Atkinson have had lengthy experience, and presumably it was as a result of this experience that some of the novelties were introduced into this chassis. If we take the firebox we find that a shute is located low down on the side for firing, the mouth of this shute being level with the footplate. As to their reasons for this, the designers say that it gives an opportunity to make use of a greater number of tubes, and therefore greater heating surface; that it avoids scorching the cab roof; and that the driver sees what is going on in the firebox. Another point to be noted is that the fuel never gets above a certain height in the firebox, giving plenty of combustion space. Another useful feature in respect of the firebox is the clinkering door at the front. A double continuous coil of piping located in the upper part of the uptake serves to superheat the steam on its way to the engine. This superheater is attached to the top plate, with which it can easily be removed after the steam pipe connections and plate joint have been broken. It is worth special note that with the chimney removed, the steam pipes disconnected, and

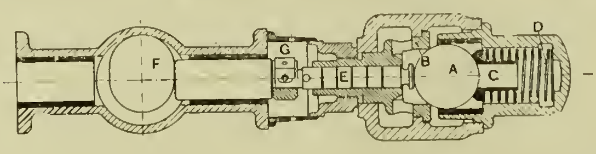


This sectional drawing explains the general arrangement of the Atkinson water-tube boiler and firebox.

the lower joint broken, the entire upper part of the outer shell can be lifted away with suitable tackle connected to two rings on the top plate, and in this way exposing firebox, water tubes, &c. The boiler may be fed either with a pump or an injector, a water heater being fitted of strong construction, and consisting simply of two cylindrical chambers, one arranged inside the other, so that the water passes through the inner one and is warmed up by the steam in the outer chamber, which is lagged. The steam in this outer chamber is,

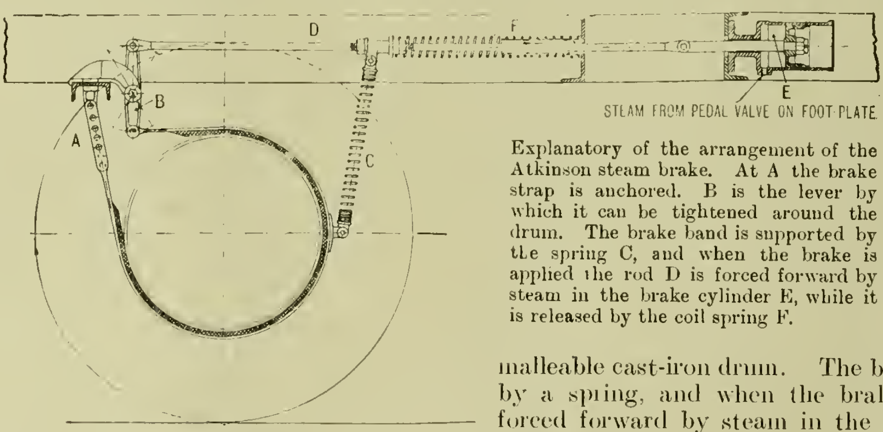
of course, from the exhaust. Any condensation that takes place in this outer chamber is led to the ashpan and sprayed underneath the firebars at each pulsation of the engine, where it has the effect of assisting the fire.

The Atkinson engine gives us quite a new departure so far as the valves are concerned. These consist merely of large steel balls on soft steel seatings, each valve or ball being held up against its seating by a brass pad actuated by a coil spring. These ball valves are pushed off their seatings by tappets operated from a camshaft, as is the case with petrol motors. The point of importance regarding these hardened steel balls




A sectional drawing of one of the very original ball valves of the engine. A is the hardened and ground ball which is pressed on to the soft steel seating B by a brass pad C actuated by the coil spring D. It is lifted off this seating by the tappet E worked off the cam F, and tappet adjustment is provided at G.

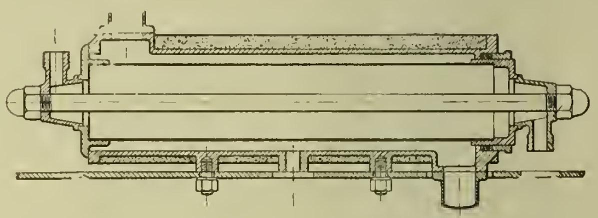
is that the same part is not successively brought on the seating, which must always conform to the shape of the ball. There are four such valves, an inlet and an exhaust, at each end, to each cylinder. Two camshafts are employed to give separate adjustment to the valves, and the inlet valves are placed above and the exhaust below the cylinders, the camshafts being carried across the cylinders above and below respectively. One shaft—the exhaust—is driven from the crankshaft by bevel gearing, and from the shaft of the latter through bevel gear and a vertical shaft is driven the inlet camshaft. Everything is carefully encased, and a small oil pump is mounted on the exhaust camshaft, which forces lubricant through copper pipes to the cams.




Explanatory of the arrangement of the Atkinson steam brake. At A the brake strap is anchored. B is the lever by which it can be tightened around the drum. The brake band is supported by the spring C, and when the brake is applied the rod D is forced forward by steam in the brake cylinder E, while it is released by the coil spring F.

In order to secure a wide variation of power, and consequently of speed, the cut-off is made variable by an arrangement whereby the camshafts can be slid so as to bring other parts of the cams under the tappets. This is accomplished by having the profiles of the cam extensions tapered. The variation of the stroke which can be secured in this way is given as from 75 per cent to 50 per cent. The former degree of cut-off is employed at starting, and the regulator gives the latter a further movement, bringing it to the neutral position, in which steam is simply blown through the cylinders. In the reverse position the cut-off is 75 per cent, a normal speed for working in a backward direction.

The back axle consists of a solid straight through shaft carrying the near side wheel, whilst the off-side wheel is carried on a sleeve on the other end of the shaft. On this wagon both the shaft and sleeve are provided with flanges, to which the sun wheels of the balance gear are bolted. Outside the balance gear casing is carried the chain wheel. Referring again to the flanges, the makers contend that these provide a more satisfactory form of attachment, and inasmuch as wear often takes place between the shaft and the sleeve, the off-side



This section of the feed water heater explains how the water is led through a central cylindrical chamber surrounded by an outer chamber containing exhaust steam, which is kept from condensation by the lagging around it. The whole heater is held together by the nuts and central rod, which clamp the two end covers on to the end of the cylindrical chamber.

wheel of the Atkinson has an annular space in its nave to contain lubricant, which finds its way between the bush of the sleeve and the shaft. Other excellent lubricating arrangements are to be noted on this chassis which need not be dealt with here.

Another important and striking feature is the steam brake, which was introduced with the idea of obtaining something powerful, and, at the same time, avoiding those stresses to which the ordinary type of brake connections are subjected. The elasticity of steam is here brought into play. The brake band is at one end anchored to the frame, and at its other end is connected to a lever by which it can be tightened around the malleable cast-iron drum. The brake band is supported by a spring, and when the brake is applied a rod is forced forward by steam in the brake cylinder, and is released again by a coil spring on the brake piston and rod connection. The steam is admitted to the piston chamber of the brake by means of a foot valve on the footplate, and can be controlled by the driver at will, so that the steam passes from the brake cylinder to the feedwater heater, and thence to the exhaust.

The front of the Atkinson vehicle is very strongly and well designed to make it easily handled in circumscribed areas. A very substantial steel tube forms the axle, at either end of which are carried bearings for the pivots of the stub axles. These bearings are halved, thereby rendering dismantling easier, whilst the stub axles are well-proportioned forgings. The road wheels

are of the cast-steel type, and are quite light for the work they do. Generally speaking, this make of wagon is one to be commended to industrial engineers as a sound job for heavy haulage.

*(To be continued.)*

## WATER POWER AND POWER TRANSMISSION IN THE UNITED STATES.*

By Dr. Louis Bell.

During the past 12 months developments in power transmission have been in the direction of consolidation rather than striking new methods.

One point of interest is the prospect of legislation affecting the use of water-power. There is, however, little danger of such a thing as a water-power trust, nor, with sane regulations, is there likely to be. At present legislative enactments have tended to restrict the free development of water-power, and have, therefore, hindered rather than helped the development of power transmission.

Another debatable question is the linking-up of transmission systems so as to cover the country with an adequate network and facilitate the free use of power. Most of the consolidating schemes of this kind have been beneficial, although in a few cases they have served as an excuse for watering of capital and no useful service served.

Every addition of an electric power station to a growing network means greater security against interruption of service and more efficient use of conducting material; with copper costing nearly 2s. a pound this is no mean advantage.

The chief technical advance is still in the direction of higher voltages. With the advent of suspension insulators the limitations of earlier days have for the most part disappeared, and with copper at its present price the tendency must be steadily upward. 50,000-100,000 is now regarded as quite reasonable, and conservative. The rapidly increasing use of outdoor sub-stations means lessened cost of supply from ramifying lines, enabling labour to be used for inspection and control rather than for idly watching the operation of transformers and switches.

The earlier high-tension switch-gear was costly, bulky and inconvenient to control. The linking-up of stations to a common system of supply is leading to greater simplification. Each plant acts as a reserve for the other, and need not be elaborately equipped for reserves. A generator and its high-tension transformer are now regarded as one unit, the units being linked together with sufficient electro-dynamic cushioning to secure safe operation.

The time is coming when networks will be regulated as a whole, and not merely in parts. The use of synchronous apparatus, loaded if convenient or unloaded if necessary, for regulating purposes has long proved its value, and is capable of giving wonderful steadiness to the performance of systems covering hundreds or even thousands of square miles.

In these days the difficulties of simple straightaway transmission are almost negligible, granted sound construction methods and reasonable care. Attention will therefore be centred more and more upon working our mass operations, a campaign of the organised armies of industrial science.

* Abstract of an article in the *Electrical World*.

## FORMATION OF CLINKERS IN BOILER FURNACES.

By Albert A. Cary.

During many years' experience in designing, testing, improving, and operating furnaces used for many purposes, no branch of this subject has been found that requires more consideration than the troublesome formation of clinkers in the furnace and the formation and growth of clinkers on furnace linings. In a great majority of cases this trouble can be either greatly reduced or avoided, for clinkers are formed by the fusion of the ash and refuse which remains after the combustion of the coal in the furnace. Ash is really a very useful material in the furnace, when it is properly taken care of there, since, with a proper thickness of ash covering the top surface of the grate, burning and warping of the bars are prevented.

Where properly-designed shaking bars are used, the thickness of the ash bed on the top surface of the bars can be easily regulated, and it is very necessary that this be properly accomplished with this type of bar, as most of the shaking grates are designed with thin, delicate edges which are easily burned or warped when brought in prolonged contact with a hot firebed. It is quite essential that the thickness of the ash bed should always be reduced before any attempt is made to break up the firebed above, otherwise the ash will be thrown up into the bed of fuel and fused into clinker.

The shaking grate improperly used may be productive of more clinker in the furnace than would occur with the plain stationary grate in use. The thickness and conditions of the firebed have much to do with this grate and clinker trouble, however. The density of the fuel bed is really of more importance than its thickness. A comparatively thin firebed that is dense and compact will hold the ash within its hot body, instead of allowing it to precipitate to the gratebars, just as much as a thicker bed, when it is more open and porous.

When any firebed is more or less solid, or compact, the air for its combustion will not pass uniformly throughout its mass, but, on the contrary, this air will search out its easiest paths of passage and flow through the irregularly scattered openings formed by cracks or holes in the firebed, and, with the ash held up in this densely packed bed, the air, rushing through these selected positions, will cause intense combustion to occur at such places, which rapidly fuses the surrounding ash into clinker, and at the same time causes the soft, pasty mass to attach to itself a considerable amount of the solid combustible fuel.

Too thin fires carried on the grates should be avoided, especially with shaking grates, as every firebed should be of sufficient thickness to allow a proper depth of ash to be carried on the bars to protect them from the intense heat of the burning fuel above them. Excepting these very thin firebeds, it may be said that the intensity of draught required to operate a furnace is, generally speaking, a measure of its clinker-making properties, which is another way of saying that the intensity of the draught required is a measure of the density of the firebed. With a properly-constructed, hand-fired mechanical grate, the writer has been able to carry a bituminous coal fire continuously (using Eastern bituminous coal) with a firebed thickness of from 12 in. to 18 in., with no troublesome formation of clinkers, and this was done with a coal consumption of between 20 lbs. and 30 lbs. of fuel per square foot of grate per hour. The whole secret of this performance was due to the fact that the accumulation of ash at the bottom of the

bed could be easily kept reduced to a desirable thickness by use of the shaking bars, while the crust or cake forming over the top of the firebed was broken up, when necessary (as well as the packing of fuel in the interior of the bed), by very slowly moving the lifting part of the grate up into the bed of fuel without disturbing the ash.

This kept the whole firebed thoroughly broken up and so open and porous that less than 1 in. draught pressure measured by a U-tube at the flue outlet (natural chimney draught) was sufficient to keep the fuel bed (averaging fully 15 in. in thickness) in a highly incandescent state. Under these conditions there was no troublesome formation of clinker that would not go through the shaking bars, and this avoidance of such trouble was emphasised by the fact that no hand-cleaning tool was used in the furnace from the beginning to the end of the week. This performance has been repeated in several plants and with a variety of Eastern bituminous coals, with the same non-clinkering results, which proved conclusively that the density of the firebed has more to do with clinkering trouble than its mere thickness.

### Clinkering in Underfeed Stokers.

The underfeed type of stoker, in its method of working, simply defies all theories for the reduction of clinker troubles. With this type of stoker the coal is fed by plungers or screws, into U-shaped troughs, with the top open surface of these retorts dropped to the upper level of the gratebars. When the troughs (or retorts) are filled, further feeding of coal by the plungers or screws will cause the coal to rise above the level of the gratebars, and above this surface is found an incandescent bed of burning fuel, into which firebed the fresh coal from the retort is forced. As the fresh bituminous coal passes upwards into the "zone of combustion" its gaseous matter is first liberated by the heat, and mixing with the air from the tuyeres (placed at the grate level) it burns as it seeks out its passage of escape through the hot fuel bed above. As fresh coal continues to be forced into the retort below, it shoves the coke above (which remains after the gaseous matter has been driven out of the preceding charge of coal) so that this burning coke becomes the upper incandescent firebed. This coke continues to be forced upwards, burning rapidly until only the ash is left which has been produced in the hot burning mass of coke and forced to the top of the fuel bed.

Very few grades of coal produce ash which will not become fused into more or less of a clinker under such conditions of treatment, and it therefore becomes necessary, where this type of stoker is used, to select a coal which does not run too high in its percentage of ash, and the ash must have the highest fusing temperature possible. By the method of feeding used by this type of stoker, it will be noted that the coal is compactly forced into a more or less condensed mass of burning fuel, which demands the use of heavy forced blast fans, and, in order to reduce the amount of clinkering which occurs, the operator must use every possible means to keep his fuel bed open and porous otherwise the air for combustion will seek every easy passage for escape, and work its way through cracks and holes in the fuel bed, instead of being more uniformly distributed throughout the mass of hot fuel.

This form of stoker has permitted the feeding of more coal per unit of grate area than its predecessors, and this valuable feature largely offsets its clinkering troubles, as the demand of to-day is for a stoker that will burn coal, and lots of it when required, to carry the plant over its troublesome peak loads.

Side walls of this type of stoker should be kept free from accumulation of ash or clinker at very frequent intervals, and before the clinker is allowed to cool and harden, to prolong the life of these walls. By a careful selection of the coal and refractory lining for the furnace the worst effects of clinker trouble can be considerably reduced.

### Clinkering on Furnace Walls.

There is a most troublesome result following the fusion of ash in contact with the side walls and bridge walls of furnaces, which frequently causes expensive repairs and necessitates untimely stoppage in the operation of the boiler, and this occurs in hand-fired furnaces as well as those equipped with mechanical stokers, although, of course, to a lesser extent.

The selection of refractory material for lining furnaces is a matter which has received altogether too little attention by power-plant owners, who are too often influenced by the most persuasive salesman who calls upon them, or else they leave the matter to their masons, who are in many cases pretty certain to buy the cheapest firebrick or else buy at the place where their commissions are the highest. The common practice of using the same quality of firebrick for all parts of the furnace is certainly a mistake. The side-wall lining of a furnace should be selected with the use to which it is subjected kept in mind It is true that these side walls are subjected to the effect of high temperatures, but if we use the most refractory bricks we can buy for this position, we shall find that they will not stand the severe abrasion to which they are subjected, such as received with the use of the poker, the clinker bar, etc., to free them from the adhering clinker, and it is most important to consider the fluxing effect on these bricks from the ash produced from the particular kind of coal produced.

An altogether different kind of service is called for in the refractory arches used over the firebed, which need a different quality of brick, and still further consideration should be given in the selection of refractories for use in special-shaped blocks and tiles used in other parts of the furnace. The fireclay brick is the one used in nearly all boiler settings, and it is probably the best brick adapted to sudden changes of temperatures, due to its more or less porous structure. The fine-ground, hard-burned brick usually gives the best linings for side walls, while the coarser and more open (or porous) bricks are better adapted for fire arches. Accumulation of ash or any incipient formation of clinkers on the side walls or bridge walls of furnace must be promptly removed without allowing them to build up if destruction of the walls is to be avoided.

With the overfeed type of stoker, with inclined grates as has been previously explained, the ash formation out of the fuel does not begin until after the burning coal has descended a certain distance upon the inclined grates. In that class of inclined grate stokers which receive coal at the front end of the furnace and pass the burning fuel slowly downwards along sloped grate bars to the rest grate at the rear of the furnace unless this fuel is constantly being agitated with a shearing motion, next to the side wall, there is a tendency for the ash to fuse and adhere to the side wall at the lower part of the furnace. Convenient poke holes are usually provided through which the fireman can slice the fire next to both side walls and thus reduce the tendency to build clinker at these positions.

In the other class of inclined grate stokers, which have their fuel fed from coal magazines placed in each side wall, feeding their fuel from these positions down sloped grates to the lower centre of the furnace, we find a reduced surface of furnace wall presented to the firebed, at the rear

and front of the furnace. At the bottom of the V, formed where the two sets of inclined grates (from each side wall) come together, there is provided a set of clinker bars which are supposed to remove the ash and clinker automatically as soon as they reach this position, but there is always an accumulation of incandescent ash, clinker, and some small amount of fuel at the bottom of this trough, which builds up, especially in the presence of large clinkers formed in the firebed, and where this lower part of the fuel bed comes in contact with the end walls there is a tendency to build up clinker or erode.

With the chain-grate type of stokers, there is a very slowly moving bed of fuel, each side of which is in contact with the side walls. With a very slow motion of the burning fuel on these grates there is a tendency with certain coals for fusion of the ash to take place, and when this comes in contact with the side walls, due to the slow rate of travel, clinkering often occurs there. Such trouble is increased when the movement of the grate is stopped for considerable periods of time. Efforts have been made to reduce the destructive action to side walls in furnaces where this type of stoker was used by substituting metal faces in the furnace walls to replace the firebrick lining, back of which faces a water circulation was maintained. Beside the clinker or erosive troubles in stokers of this type there is added the abrasion caused by the constant rubbing of the fuel bed against the side walls. Notwithstanding the occurrence of such troubles in certain plants using this type of stoker, there are many hundreds in use where firebrick linings are used in their furnaces, and it is claimed that the cost of repairs for these linings is not excessive, and that it is no higher than in other stokers doing similar service.—"Electrical World."

## TAR OIL FUEL AND DIESEL ENGINES.

By Geoffrey Porter, A.M.Inst.C.E.

*(Continued from page 439.)*

I have been particularly interested in examining indicator cards of engines burning residual petroleum oil, tar oil alone, and tar oil with the addition of a pilot jet of residual petroleum oil. More especially I desired to ascertain the conditions of temperatures in the cylinders, and to investigate the statement often made to me that the use of tar oil produces greater temperatures than does the use of a residual petroleum fuel oil. I agree that a higher temperature does result, but the increase is not of high value when allowance has been made for the slower burning property of tar oil by advancing the fuel admission. The question of excessive increase of temperature seems to be, as one might anticipate, bound up with valve setting.

Mr. Still, Mr. Prentice, and Mr. Strickland have been exceedingly kind in sending me indicator cards taken from the engines under their control. My only disappointment in this connection is that the conditions of engine loading under which the cards were taken were not more closely in agreement. It would be unreasonable in these days to ask engineers to carry out tests or to specially adjust their engines for the purposes of the writer of a paper such as this. But I have the satisfaction of knowing that the cards represent actual running conditions, and are therefore possibly more valuable than they would have been had they been taken after careful preparation.

The figures quoted later do not pretend to great accuracy. In several particulars it has been necessary to make assumptions, such as the value of clearance volumes and initial temperatures. The assumptions were made on similar lines for each engine, and the figures serve for comparative purposes.

The starting cards I have been able to obtain appear to be normal; I have not detected any difference of consequence between such cards taken from engines running on the fuels mentioned. In the engine fitted with pilot jet ignition gear under my own charge sudden pressure increases occur occasionally at starting. Though I have made many attempts to record one of these irregularities I have so far been unsuccessful. Abnormal starting pressures can be manufactured easily enough by feeding paraffin oil to the air valves, but an artificial condition at starting does not lead to results of actual value.

Nearly all the cards in my possession, taken at fairly high fractions of full load, are of good shape. I believe that all of us who have used tar oil, with or without pilot jet ignition gear, have found it necessary to advance the fuel admission, the setting for residual petroleum oil being generally too late for the slower burning tar oil. Some of the earlier cards taken by myself were of a very indifferent appearance, showing late admission and late combustion, conditions that were confirmed when the cards were worked out. In general a card taken from an engine using tar oil with pilot jet ignition is not so nicely shaped as a card taken with residual petroleum alone, or with tar oil alone as fuel. The prior ignition of the pilot jet produces a "peaked" admission line in comparison with the regular, slightly-drooping curve which denotes combustion at constant pressure.

A few figures obtained by calculation from cards I have taken or received from other engineers may be of interest. Incidentally I should like to say that a very interesting paper might be read on the subject of indicator diagrams taken under the various conditions arising from the use of fuels other than residual petroleum oils.

A set of cards from a 4-cylinder 200-B.H.P. engine driving a 125-kw. direct-current dynamo, using residual petroleum as fuel, gave the following particulars:—

| Cylinder. | Ind. H.P. | M.E.P. | Max. Temp. Fah. abs. | Temp. at exhaust. Fah. abs. |
|---|---|---|---|---|
| | | lbs. | | |
| 1 | 48·5 | 77·0 | 2560 | 1745 |
| 2 | 47·1 | 74·8 | 2580 | 1658 |
| 3 | 53·7 | 85·3 | 3010 | 1745 |
| 4 | 51·3 | 81·5 | 2799 | 1865 |
| | Total 200·6 | average 79·6 | average 2737 | average 1753 |

On entering the corresponding figures for a number of points on the diagrams in a theta-phi chart the customary curve appeared to be of a tolerably good shape. The engine was indicated at a load equivalent to 77·4 per cent of full load. The engine was running under ordinary conditions at the time, no care being taken to adjust valve settings, etc. The cylinders are not quite evenly loaded, the maximum difference being about 11 per cent.

The next set of figures relate to cards taken from the same engine when burning tar oil with a pilot ignition jet of petroleum residual oil amounting to 12 per cent of the weight of tar oil. The generator loading was 83·6 per cent of the normal full load rating, *i.e.*, 8 per cent

in excess of the load in the previous example. The diagrams yield the following particulars :—

| Cylinder. | Ind. H.P. | M.E.P. | Max. temp. Fah. abs. | Temp. at exhaust. Fah. abs. |
|---|---|---|---|---|
| | | lbs. | | |
| 1 | 56·1 | 85·4 | 2860 | 1575 |
| 2 | 59·4 | 90·5 | 2875 | 1805 |
| 3 | 61·1 | 93·1 | 3048 | 1965 |
| 4 | 53·8 | 82·0 | 2805 | 1741 |
| | Total 230·4 | average 87·75 | average 2897 | average 1771 |

The corresponding temperature entropy diagram is moderately good. The temperature stated at exhaust for No. 1 cylinder is, I think, too low, probably due to an error in measurement. Neglecting this temperature, the average temperature at exhaust opening is 1,837 Fah. abs. Taking into consideration the difference in the engine loading, neither maximum nor exhaust temperatures appear to differ much for either class of fuel oil. These results were worked out from cards taken from the engine in which I am interested personally.

Mr. Prentice has sent me a set of cards taken from an engine at Felixstowe. These cards interested me very much, as tar oil is used as fuel without the assistance of a pilot ignition jet. Beyond starting the engine on residual petroleum oil the tar oil is relied upon solely. The load factor of this engine is so good that this course can be adopted safely. It is conceded generally that tar oil used alone is satisfactory when the engine is loaded to 75 per cent of normal full load rating and upwards. I have been able to corroborate this fact on my own engine, but its running conditions do not permit safe or satisfactory operation without the pilot jet. Mr. Prentice's cards refer to the same engine using tar oil in one case and residual petroleum in the other. Unfortunately, only one card for each condition is sufficiently legible to enable any results to be calculated. The engine dimensions are: Three cylinders, 14¼ in. diameter by 22½ in. stroke, at 190 revolutions per minute. The following figures give the results obtained from one card of each set :—

*Fuel—Tar Oil alone; Loading equal to 91 per cent of Normal Rated Full Load :—*

| Ind. H.P. | M.E.P. | Max. temp Fah. abs. | Exh. temp. Fah. abs. |
|---|---|---|---|
| 85·6 | 101·25 | 3105 | 2055 |

*Fuel—Residual Petroleum Oil; Loading—85 per cent of Normal Full Load :—*

| | | | |
|---|---|---|---|
| 78·8 | 93·1 | 3095 | 2210 |

The card taken with residual petroleum fuel oil, unfortunately, shows that combustion is taking place almost down to exhaust point, so the results are not strictly comparable. For this reason I should have been glad to have been able to work out the companion cards. The tar oil card has a beautiful shape, and would adorn a textbook.

I have also had the opportunity to work out two complete sets of cards given me by Mr. Still. They were taken from the same engine, burning tar oil alone in one instance and tar oil with a pilot jet of residual petroleum in the other. The engine dimensions are: 300 B.H.P., three cylinders, 26 in. stroke, 17 in. diameter pistons, 170 revolutions per minute. I obtained the following figures:

*Fuel—Tar Oil only (Class of Oil as Sample "C 1") :—*

| Cylinder. | Ind. H.P. | M.E.P. | Max. temp. Fah. abs. | Temp. at Exhaust Fah. abs. |
|---|---|---|---|---|
| 1 | 108 | 85·9 | 2705 | 1610 |
| 2 | 106 | 84·3 | 2830 | 1985 |
| 3 | 106 | 84·5 | 2625 | 2080 |

The cylinders are very evenly loaded. This is a detail more easily regulated when fuel is supplied from a central distributor as with this engine than with engines where each cylinder is fed from a number of pumps driven by the same mechanism. The cards when using a *pilot jet* gave the following particulars :—

| | | | | |
|---|---|---|---|---|
| 1 | 114 | 90·3 | 2815 | 1755 |
| 2 | 111 | 88·2 | 2826 | 2050 |
| 3 | 109 | 86·3 | 2725 | 2410 |

The loading of the engine was the same for each set of cards, viz.: 78·3 per cent of the rated normal full load. The results obtained with the pilot jet ignition show a higher mean effective pressure by 4 per cent, taking the mean for the three cylinders in each instance; while the average maximum temperature is 2·5 per cent higher for the second set of cards. This is to be anticipated owing to the greater quantity of fuel injected into the cylinders when using the pilot jet, but, naturally, the efficiency of the engine is slightly reduced. This effect can only be seen definitely by comparing the results obtained from Mr. Still's engine, because the other two engines were not run on the same loads when indicated with each fuel oil.

In the second set of figures from Mr. Still's engines the comparison of temperatures cannot be made as exactly as could be wished because the third cylinder in the second series shows evidence of late combustion to the end of the stroke.

I judge by the above figures that the use of tar oil increases the temperatures to a slight extent, but not excessively unless the valve settings are unsuitable for the quality of the tar oil.

*(To be continued.)*

## GAS TURBINES.

In the course of a short paper on "Gas Turbines," recently read before the Junior Institution of Engineers, Mr. S. E. Hutson stated that the great hindrance in the way of the development of the gas turbine as a commercial unit was the, at present, insurmountable difficulty of finding a metal which would withstand the extremely high temperature of the gases. He referred to the general lines along which most gas-turbine designers had proceeded, and showed that practically all the experimental machines which had been built were based upon one of three principles. The first involved the use of a combustion chamber lined with refractory material into which some form of fuel was forced, together with such an amount of compressed air as was

necessary for combustion. The gases were ignited in this chamber, and were then directed on to the buckets of an impulse wheel after passing through diverging nozzles. The air and fuel were driven into the combustion chamber by means of pumps or compressors, which took power from the turbine. The second type of turbine was based on much the same principle as the first, but was fitted with a water jacket, which surrounded the combustion chamber. The third principle, which the author considered the most feasible, and upon which he had himself been working, was described as the regenerative principle. In this case a charge was forced into the combustion chamber, surrounded by a water jacket, and, after combustion, was brought down to a temperature more suitable to the turbine blading, on to which it was passed through nozzles. The reduction of temperature in the combustion chamber was brought about by steam generated in a special type of boiler placed in the path of the gases as they exhausted from the turbine. After briefly describing several of the experimental machines which had been built by British and Continental engineers, Mr. Hutson described the designs of a turbine for which he was largely responsible. This design was based upon the regenerative principle, and in many points showed considerable ingenuity; but Mr. Hutson had found himself up against most of the difficulties which had confronted other experimentalists, and, as he admitted, his efforts had been attended with as little success as theirs. In the first place, he had been unable to obtain a suitable material to withstand the high temperature of the gases. He had, moreover, found that in nearly all the experimental turbines which had been built the fuel and air compressors had consumed a very large percentage of the output of the machines, but on his machine Mr. Hutson had naturally had to resort to the use of a feed pump to get the water into his boiler, which was an additional drain upon the power developed by the turbine.

## THE PROBLEM OF AEROPLANE ENGINE DESIGN.

By Charles E. Lucke.

*(Continued from page 424.)*

So much for the facts. An analytical engineer cannot be content with those facts, however, but finds it necessary, if he is to apply a cure, to go behind the facts to ascertain the reasons. The first step in doing that is to determine the volumetric efficiency of the engine by measuring the air and fuel, and comparing the total volume of mixture taken in, with the piston displacement. If the volumetric efficiency be plotted against the speed, much light is thrown on the situation. In the first place the volumetric efficiency falls off in the region of very low speed, where the main effective pressure is low; it is constant over the region of constant mean effective pressure, where the horse-power speed line is straight, and then at some high speed it again decreases. It is clear, therefore, that curvature of the horse-power speed line is due to a corresponding variation of volumetric efficiency. It may be found, however, that at some high speed the horse-power speed line falls before the volumetric efficiency. This calls attention to the fact that the falling off of mean effective pressure at high speeds may not be due primarily to volumetric efficiency, but to other causes, and recognition of this starts a search for those causes.

The first of these causes is too slow a combustion, or too high a piston speed. That is to be corrected by adding an additional ignition source, or by moving the spark plug from a side wall to a centre point. Igniting at more than one point or at a more central point will cure this defect, and again cause the dropping points of both horse-power speed and volumetric efficiency speed curves to lie on the same speed line.

Again, it will be found that a change in the valve setting changes this mean effective pressure curve at both ends, but every change in the valve setting also changes the mean effective pressure, and the volumetric efficiency is itself the direct measure of whether or not one has the best valve setting.

Now, it is curious that most people have played with cams and adjusted them back and forward by guesses, and have never bothered about the air meter, which is the only positive means of arriving at best cam forms and valve timing for sustained mean effective pressure at high speeds.

Many more analyses along the above lines could be given, but enough has been said to call attention to this most important means of studying the problem of maximum power at high speed, not only revealing what is the matter, but pointing out clearly the direction in which to correct the fault.

So much for efficiency and mean effective pressure, or efficiency and horse-power per cubic foot of cylinder. These two factors bear directly on the fuel weight to be carried and the output per cubic foot of cylinder. What will be the weight of that cubic foot of cylinder? This has to be judged both by qualitative and quantitative analysis. It is impossible to give any quantitative analysis without long mathematical treatment, so I will undertake only the qualitative analysis.

The first point in qualitatively analysing unit metal weight of the multi-cylinder engine is to recognise that the engine can be divided laterally by planes into sections of one cylinder each. The end sections are the same as each other, but are different from the intermediate sections. Therefore, to study qualitatively the relative weights of two typical constructions, the mind must be concentrated upon these sections, each one of which includes a cylinder, a piece of frame, a piece of shaft, and the other parts that go with the section.

From this point of view, consider multiplication of cylinders in line *versus* radially or circumferentially. It will appear that the weight of the cylinder, piston- and connecting-rod, is just the same, no matter how the cylinders are arranged, but the frame weight and shaft weight are reduced by any multiplication. It is clear also that, other things being equal, the lighter arrangement is circumferential rather than longitudinal multiplication.

*(To be continued.)*

## TREATMENT OF HYDROCARBON FUELS.

By H. G. Chatain.

*(Concluded from page 426.)*

In passing from the utilisation of kerosene, the next logical step is to the very heavy hydrocarbons, and although there is still a great deal to be accomplished in this field, much has already been done. For comparatively large powers and for diverse purposes the high-compression oil engine (an engine in which the compression goes to 500 lbs. per square inch or thereabouts) is an accomplished fact, hundreds of thousands of horse-power being in daily use throughout the world. A brief description of its principle is as follows:—

The 4-stroke cycle and the 2-stroke cycle are used, and

each has its advocates who claim their respective superiorities. Pure air is taken or admitted to the interior of the cylinder. This is compressed to 500 lbs. per square inch or thereabouts, and at a point approximating the upper dead-centre of the piston or slightly before, fuel is injected in the form of a fog or fine spray, and upon coming in contact or commingling with the highly-heated air in the interior of the cylinder, inflammation results. This obviously increases the temperature of the air, which in turn is expanded.

Up to the present time, of all the devices used in rendering the combustible fit for consumption, the accepted form is the air injector. The function of the injector is to receive a definite quantity of combustible per cycle, which is usually propelled to the injector by means of some form of pump. It is immaterial at what portion of the working cycle of the engine this oil is delivered to the injector, provided it goes there in the proper quantity and in synchronism with the rotative speed. The quantity is a function of the load on the engine. To this same injector device, air is led from a pump or suitable container under pressures varying in practice usually from 800 lbs. to 1,300 lbs. per square inch. The injector is also equipped with a cam or otherwise actuated needle valve. This needle valve being opened on or slightly before the upper dead-centre of the piston is reached, permits the contents of the injector to come out in the form of fog or fine spray. Another part of the injector of great importance is known as the flame plate. Its function is to divert in the proper direction the incoming spray, or fog, from the injector. This is usually accomplished by one or several small holes of suitable size pointing in the proper direction.

This pointing in the proper direction brings up a very important feature in regard to utilising combustible in this manner. It is essential that the entire combustion chamber be filled simultaneously, or as nearly so as possible, with the combustible. If the flame plate was arranged to distribute the combustible in only one-half of the cylinder, the power and output of the engine would go down to an appreciable extent. In this respect I wish to emphasise that the high-compression engine is distinctly different from the engines utilising fuel that has been admitted prior to the compression stroke. In this instance the compression stroke serves to a great extent to thoroughly mix the combustible with the air, and presents a homogeneous mass at the time the inflammation is started. The development of the art is such that with the injector, as described and commonly used, it is possible to operate an engine at rotative speeds as high as 550 or thereabouts. Although fulfilling my theory in regard to great power to destroy the viscosity of the oil, the accepted type of injector to-day operating a 1,000 lbs. pressure per square inch is still incapable of furnishing the necessary force to operate properly at speeds higher than previously stated. The time necessary for the oil and air to go through the circuitous passages of the holes of the flame plate, all of which are apparently essential in the breaking up of the fuel, is excessive when we contemplate utilising this device for high rotative speeds or in engines for automotive purposes.

It is essential in the design of an injector to so construct it that oil will make its way to the combustion chamber in advance of the injection air. The reason for this will be better understood when one considers that the injection air is expanded from 1,000 lbs. per square inch down to 500 lbs., with attendant refrigerating effect, which tends to decrease the temperature of the immediate surrounding air and render combustion slower and less positive. A number of attempts have been made to discard the injection air and resort to solid injection. Nothing of this character has ever been attempted in America, at least so I believe. An English firm of note, however, has apparently carried this line of investigation to a point where it is at least workable.

In regard to internal-combustion engines of the high-compression type there is one very important feature which apparently so far has not been given a great deal of thought; that is, with the most approved type of injector and all in excellent operative condition, it is still necessary to have some 40 to 50 per cent excess air in the cylinder to produce perfect combustion. If the engine is overloaded, smoky exhaust is produced, meaning that the inflammation is not completed during the working stroke. Obviously this is a waste of fuel, not to mention the detrimental effects upon the mechanical parts of the engine. This is indeed a most important point, because if a greater percentage of the air which is taken in per cycle could be carburetted and utilised, the size of the engine could be reduced. I have long believed that a big step in advance is due and is coming when other means are devised for subdividing the incoming fuel into finer particles than is done at present, permitting each tiny particle to become thoroughly oxygenated in the shortest possible time. It is possible that an entirely different shaped combustion chamber than the existing types should be used; that is, a combustion chamber that will be constructed in a shape to conform with the jet of incoming fuel.

I have been asked many times if it would not be possible to apply the existing principles of the high-compression oil engine to motors that would be suitable for automobiles and kindred purposes. Invariably the question has been answered, that the existing types so far are not applicable, but it must be frankly admitted that there is no really inherent reason why such a motor could not be built. It means carrying out in a proper manner the basic principles underlying the existing types, but it also means a careful study of all the mechanical parts, and a re-design along rational lines of the device now used for carburetting or breaking up the fuel and rendering it fit to be used in the motor. When it becomes thoroughly understood that these motors can be made to operate for less than ½ lb. of fuel per brake horse-power per hour, and the price of existing fuels becomes higher, the proposed idea will come about and become a reality.

Some form of 2-stroke cycle engine would adapt itself better for this class of service than the 4-stroke cycle. The reason for this is that in the 2-stroke-cycle engine of this category the compression pressures used, of 500 lbs. per square inch and over, would be sufficient to counteract the inertia of the reciprocating parts, with the result that the pressures on the piston pins and crankpins would always be downward or in the same direction. As this would be the case, the trouble of taking up bearings for quiet operation would be done away with. It would appear that it would be advisable to experiment and investigate along the lines of solid injection utilising extremely high pressure, possibly as high as 6,000 lbs. or 7,000 lbs. to the square inch, rather than go to the complication of utilising air for this purpose, with its attendant multiple-stage compressor and paraphernalia. It is barely possible that experiments conducted along the line of especially preparing fuel prior to its use in the motor might materially assist in solving the problem.

The fuel question is a serious one at the present time, but it is my belief that it is but temporary. The path of

least resistance will undoubtedly be the application and utilisation of kerosene, not as attempted through the use of existing types of carburetters, but with a device distinctly constructed and embodying the requisites for the purpose. When such a device is brought about, it will permit the utilisation of enormous quantities of this class of petroleum, which is now more or less of a drug on the market. The next step, and especially for commercial purposes, will be the utilisation of the heavier category of petroleum and such other oils as tar oil and oils from the lignites, deposits of which in the great North-west are almost limitless.

It should be borne in mind that in an injector the following qualifications are desirable: (1) The particles of oil should enter the cylinder prior to an injection of air. (2) The breaking up of the fuel is better accomplished if the oil meets the injection air in some portion of the injector at right angles. A circuitous passage is obviously desirable, but its resistance should not be too great in cases where a great number of injections are required per minute, as this delays the delivery of the fuel to the heated air contained in the cylinder, and also delays the total inflammation of the mass.

*(Concluded.)*

## NOTES ON THE CONSTRUCTION OF TURBINE-PUMPS.*

By Alan E. L. Chorlton.

The turbine has become so highly successful as a pumping engine for duties of all description that no apology is needed from the author for again returning to the subject and offering a few practical notes on the design and construction of its detailed parts.

In passing, it is interesting to refer on the theoretical side, to the early French works of M. Poncelet (1838),* and M. Combes (1843),† on reaction wheels generally; also to the two papers on the mathematical principles involved in the centrifugal pump by Mr. Andrew J. Robertson in the

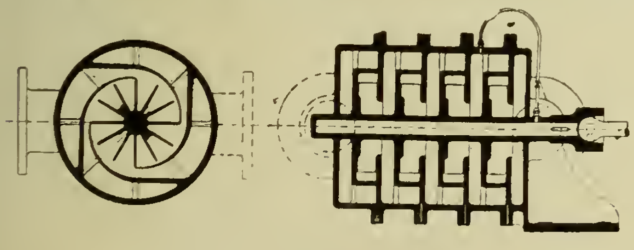


Fig. 1*a*.—(Osborne Reynolds.)

Proceedings of this Institution, 1852 and 1853, culminating in the classic work of Dr. Unwin in the Proceedings of the Institution of Civil Engineers 1877—1878. Early practical applications of accepted principles have been given by such work as that of Mr. Appold, 1848-1851, with his well-known pump, Professor James Thomson,‡ with his vortex or whirl-chamber pumps put down in 1852 to 1858, and by Mr. R. C. Parsons in experimental work described in a paper read before the Institution of Civil Engineers in 1877. Latterly practical development has been furthered by experimental

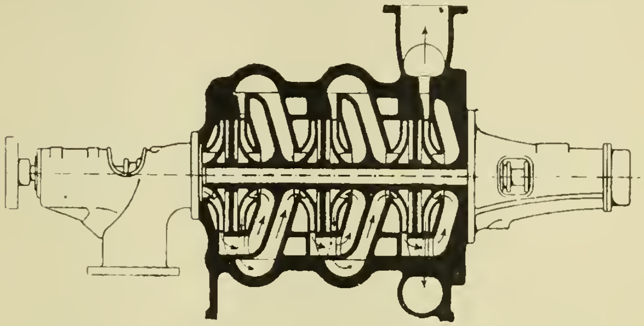


Fig. 2*a*.—(Sulzer).

work on the efficiency of centrifugal pumps by Dr. Stanton, and published in the Proceedings of this Institution in 1903, by the experiments on the fluid friction of rotating discs carried out by Dr. Unwin and described in the Proceedings of the Institution of Civil Engineers, Vol. LXXX., and

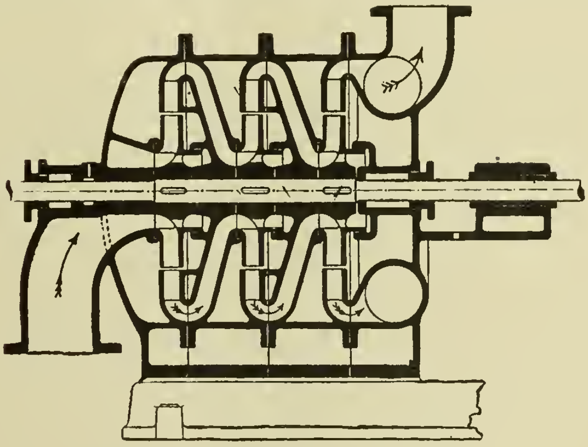


Fig. 1*b*.—" Ring-type " Construction.

more recently by the very valuable work of Professor Gibson,§ extending over wide ground both directly and indirectly affecting the centrifugal pump. There are milestones in the history of the

* Paper read before The Institution of Mechanical Engineers.

* " Mémoire sur les turbines de M. Fourneyron," read at " l'Academie des Sciences," 6th August, 1838.

† " Recherches Theoriques at Experimentales sur les roues a Réaction ou a Tuyaux," by M. Chas. Combes, Paris, 1843.

In which M. Combes refers to his own experiments, and also to the turbines of several other makers, and to the centrifugal pump of M. Demours, 1732.

‡ Thomson whirl-chamber pump put down at Low Lodge Mill, near Belfast, in 1852. Another designed for Land Drainage in Jamaica in 1853, and made in Glasgow by Messrs. W. and A. M'Onie and Co. Also a third built by Jas. Ewing and Co., of Glasgow, for Demerara in 1858.

*See* Papers read before Institution of Engineers in Scotland, vol. 1, page 90, and " on a Centrifugal Pump with Exterior Whirlpool constructed for Draining Land," read 27th October, 1858.

§ " On the Flow of Water through pipes and passages having converging or diverging Boundaries," Proceedings, Roy. Soc. A. vol. lxxxiii., 1910, page 366, 1910.

" On the Resistance to Rotation of discs in water at high speeds," Proceedings, Inst. C.E., vol. clxxix, Session 1909-1910, Part 1.

" On the resistance to flow of water through pipes or passages having diverging boundaries," Trans. Roy. Soc. Edinburgh, vol. xlviii., Part 1 (No. 5), 1911.

" The loss of energy at Oblique Impact of Two Confined Streams of Water," Trans. Roy. Soc. Edinburgh, vol. xlviii., Part IV. (No. 28), 1912.

" The design of Volute Chambers and of Guide-Passages for Centrifugal Pumps," Proceedings, I.Mech.E., 1913, page 519.

evolution of the centrifugal pump, yet the wide extent of its successful practical application in turbine form is due to the overcoming of practical difficulties both mechanical and hydraulic. This work has only been accomplished after prolonged experience, and success has only been reached after tedious and careful study and improvement of small details.

The object of the present paper is to describe and trace the development of some of the methods of successfully overcoming the difficulties referred to, and to draw attention to points in design which are

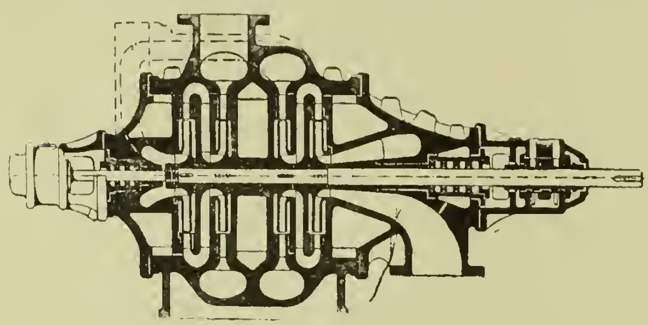


Fig. 2*b*.—Continental Pump. "Cylindrical-casing" Construction.

the result of the Author's experience extending back to the infancy of the application of the turbine-pump principle.

It will be convenient to consider the subject under the headings of the various component parts of a pump. These are:—

I. The Stator, which consists of (I *a*) the casing or housing and (I *b*) the guide-vanes or appliance for converting velocity energy into pressure energy.

II. The Impeller (considered separately).

III. The Balancing Appliance—hydraulic or mechanical.

IV. The Rotor, considered as a whole, and including the spindle with its projecting sleeves, impellers, and in most cases the balancing appliance.

V. The Bed, and other details, bearings, stuffing-boxes.

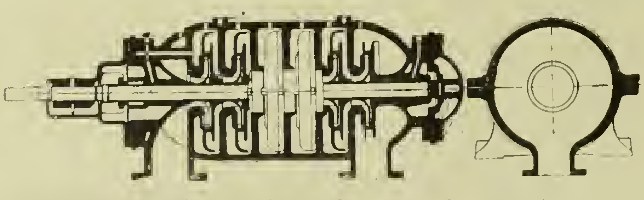


Fig. 3.—Split "Cylindrical-casing" Construction.

Of these components III., IV., and V., broadly speaking, are the factors governing reliability and resistance to wear, and I *b* and II. are those determining the efficiency.

The author proposes to deal at greater length with III. and IV., for the reason that they have probably been less discussed than the others, also their practical importance is of the greatest moment, and he cannot deal with the whole subject adequately within the confines of a paper written during the present time.

The chief points only of items I., II., and V. will be briefly reviewed:—

I. Casing.—The individual impellers of a turbine-pump revolve in chambers or cells containing the outward flow guide-passages, and the return conduits for the water; these chambers may be part of a whole in which the outer body is cast in one piece, or, an aggregation of a number of distinct cells without any outside envelope.

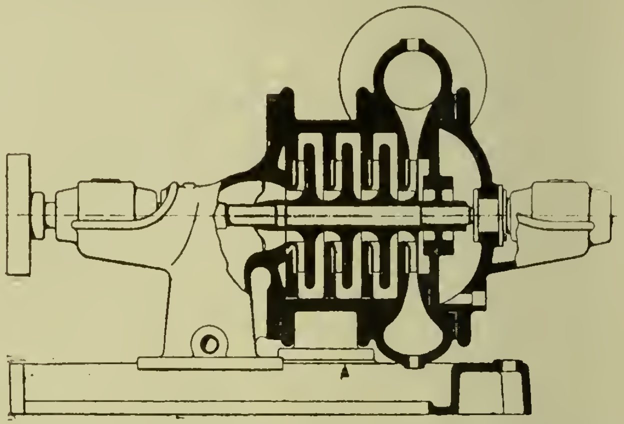


Fig. 4.—Combination of "Cylindrical" and "Ring" Features.

There are therefore two main types:—

(1) The Osborne Reynolds or divided type, and sometimes called the "ring-type."

(2) The Sulzer, integral or one-piece type, sometimes called the "cylindrical" type. Recent American practice provides a variation of this type with the housing in halves divided on the horizontal centre line.

The two main types are diagrammatically illustrated by Fig. 1 (*a* and *b*) and Fig. 2 (*a* and *b*) with variations in Figs. 3 and 4.

The Osborne Reynolds pump and its evolution was dealt with by the author in collaboration with Dr. E. Hopkinson, in some detail in a paper read

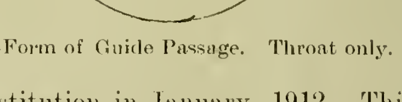



Fig. 5.—Form of Guide Passage. Throat only.

before the Institution in January, 1912. This type was followed at a later date by the integral one of Sulzer, which had, for a period, a considerable vogue. An examination of the present-day practice of various makers will prove, however, that the ring-type has ultimately proved the preferred one. The Reynolds pump* has always used a separate cell for

* First patented No. 724 1875. It is interesting to note that the drawing in this specification shows a pump which is practically Professor Jas. Thomson's turbine reversed.

each impeller, and it is therefore correct to say that the ring-type of pump owes its inception to this country.

The Continental form of the series turbine-pump is due to Sulzer (first pump 1896), and in this type a monoblock housing was used for all the chambers

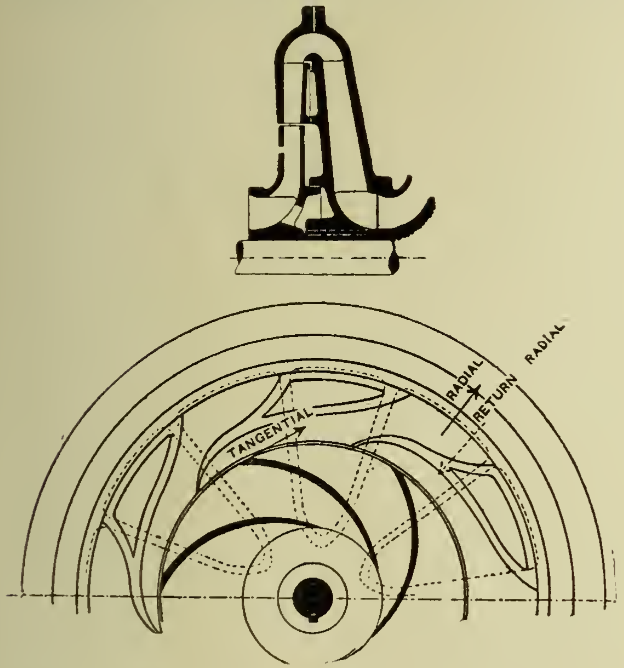
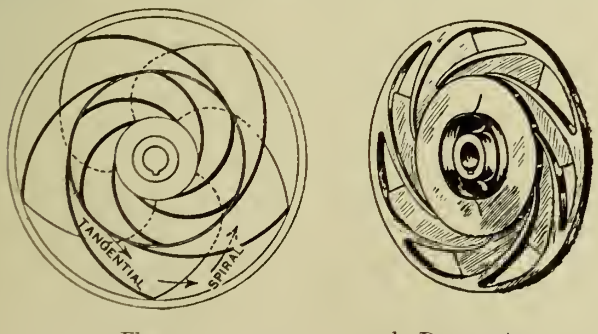



Fig. 6.—"Stage" or "Cell." Flow tangential and radial, return radial.

or cells, the guide-vanes being inserted from the end.

Before dealing with either type or variations arising out of them, it is advantageous to consider the essential functions of the chamber or housing of a turbine-pump. Primarily, each cell consists of (1) the outward flow guide-passages in which the kinetic energy of discharge from the turbine-impeller is converted into static head, and (2) the return water-passages back to the centre for conduction to the next impeller; a complete housing is a collection of such cells.




*a.* Flat. *b.* Perspective.

Fig. 7.—Flow tangential and spiral.

Obviously, in the design, commercial considerations must have a material guidance on theoretical claims. Against the requirements for best theoretical conversion of kinetic energy must be matched the allowable limits of dimensions conformable with commercial possibilities, and, in the interests of efficiency, special attention must be paid to the arrangement and dimensions of the divergent channels or guide-passages. As is well known, the form for guide-passages is represented diagrammatically by Fig. 5, and this passage must be disposed in some form to lie conveniently in the desired casing. The general character will be either a simple outward flow type in one plane, Fig. 6, or a mixed type outward and axial in two planes, see Fig. 7 (*a* and *b*) and Fig. 8.

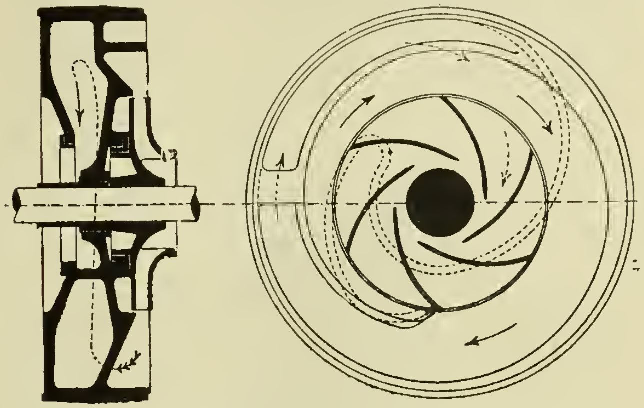


Fig. 8.—Single "Cell," single passage only.

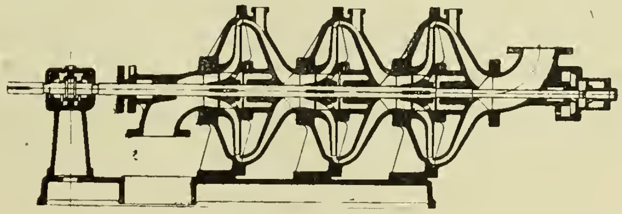


Fig. 9.—(Marchand).

The divergent angle of guide-vane, Fig. 5, for best efficiency was shown by Professor Gibson* to be 10 deg. to 11 deg. In many cases such a small divergent angle leads to a large overall diameter guide-vane in order to give a sufficiently reduced speed of water to permit reversing its radial direction, and the result is a very heavy casing in conse-

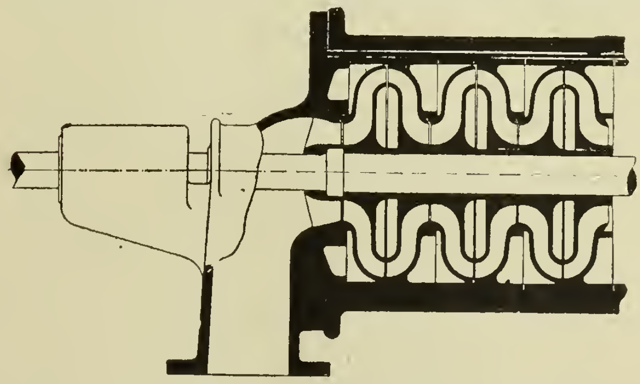


Fig. 10.—Combination of Tangential, Axial and Radial Flow. (Escher, Wyss.)

* Divergent angles have been most thoroughly investigated by Professor Gibson, *see* Proceedings, Roy. Soc. A. vol. 83, 1910, and Trans. Roy. Soc. of Edinburgh, vol. xlviii, Part 1, No. 5, 1911, etc.

quence. For this reason divergent angles of 15 deg. are commonly found in practice. Evidently a more efficient pump will sometimes be heavier and more expensive than one less efficient, and commercial considerations must provide the final deciding factor between efficiency and weight. There is, of course, a school of design which believes in dealing with a proportion of the velocity conversion in the wheel itself, thus leaving less to be dealt with

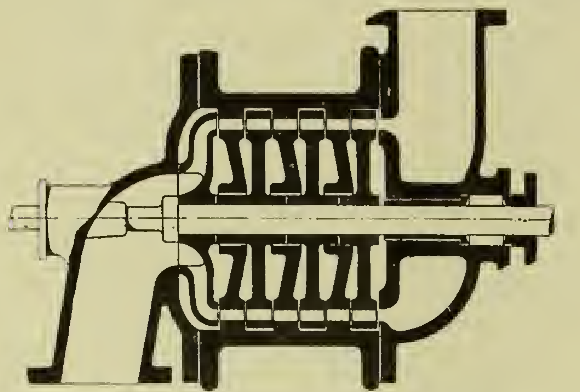


Fig. 11.—Combined Axial and Spiral Flow.

in the guide-passage; the extent, however, to which this method can be used for weight saving is very small, if any.

The various assemblies of passages may clearly be grouped into:—

(A) Tangential and radial with return radial (*see* Fig. 6 and Fig. 1 *b*).

(B) Tangential and spiral (*see* Fig. 7 (*a* and *b*) and Fig. 8).†

(C) Combinations (*see* Figs. 9, 10, and 11).

The Osborne Reynolds pump (1887 and 1875 type) employed an early form of the (B) assembly, and has adhered to this type up to the present day, various improvements being embodied from time to time, in some of which the author was concerned. On the Continent Messrs. Sulzer introduced in 1896 design (A), and the author believes they have made little departure from the type beyond a considerable simplification of their early arrangement of passages, Fig. 2 *a*.

Speaking generally, combination designs (C) are not so efficient as the simpler types (A) and (B), owing probably to the hydraulic loss through changing the radial direction of the water at high speed.

(*To be continued.*)

## WORM GEAR AND WORM GEAR MOUNTING.

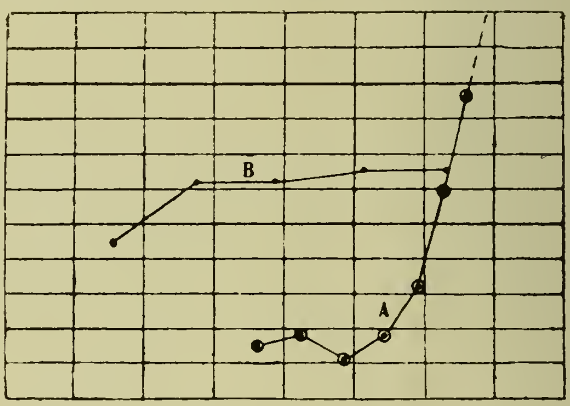
By F. W. Lanchester, M.Inst.C.E. (Member of Council).

(*Continued from page 418.*)

### PART I.

There are a great number of variables—an inconveniently great number of variables—in the design of worm gear upon which its efficiency depends. Without digesting the problem, the factors are very numerous; there are thus the diameters of the worm and the wheel and the gear ratio, also the velocity of rotation, and the torque or the horsepower transmitted (either may be specified). Beyond this there is the degree of approximate contact between the pressure surfaces, and there is the question of lubrication. The author's theoretical treatment is based definitely on the fact that the first group of variable factors, namely, the diameters of worm and wheel, the gear ratio, the revolution speed and torque transmitted, can all be represented from the point of view of efficiency in the one quantity, the pitch angle of the tooth and an assumed constant angle or coefficient of friction. For any set of gear between wide limits of load and speed the angle of friction is in fact almost constant, quite near enough so for the purposes of the foundation theory. On this assumption (*i.e.*, angle of friction = constant), it is then easy to demonstrate that the efficiency will be constant for all variations of torque and speed, and also that the efficiency is independent of the diameters of the gears provided that the pitch angle of the teeth is the same. The approximate truth of this as an experimentally established fact is the justification of the method, and this has been fully established by the N. P. L. tests and report.

In Fig 1 is reproduced Fig. 42 from the previous paper in which a comparison is given between one of the tests from the N. P. L. report and one of the so-called tests of a parallel worm cited by Mr. Kerr-Thomas, namely, from a paper by Professor Kennerson. Here, B, we see the N. P. L. test of a Daimler-Lanchester worm in which from about 27 H.P. to 62 H.P. the efficiency does not vary more than one-third of 1 per cent, whereas in the plottings from Professor Kennerson's paper, A, there is a curve which ranges from 35 H.P. to 65 H.P. over a




Worm Gear.—Fig. 1.

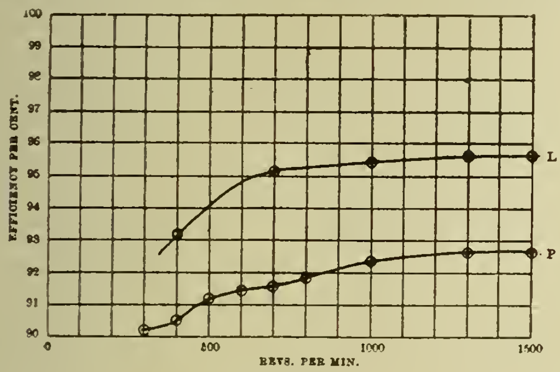
variation of 8 per cent. Now in the results taken with the author's dynamometer, which is certified by the N. P. L. to be true within one-fifth of 1 per cent (1 in 500) and is probably ordinarily within 1 in 1,000, a considerable range of load was found in every case, over which the efficiency was virtually constant both in the Lanchester and parallel types, and similarly the efficiency was also virtually constant over a considerable range of speed, though here the variations were, perhaps, somewhat greater. The author showed that there is every reason to suspect the accuracy of Professor Kennerson's results, and at the outset the results of the N. P. L. tests are taken as showing that this approximate constancy of the efficiency over a certain working range for any given set of worm gear is an established fact.

The author's own tests (on his dynamometer) of worm gear of the parallel type show clearly the same characteristic feature, namely, the approximate constancy of the effi-

† *See* Hopkinson and Chorlton Patent No. 8855—1904.

ciency over a considerable range of velocity. Two typical curves are given in Fig. 2.

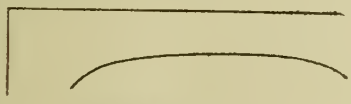
There are two conditions under which it would appear that the efficiency invariably shows a falling off; firstly, when the load per tooth for any given pair of gears exceeds a certain value, the other is when the tooth-rubbing velocity is less than a certain value; also there is, without question, a falling off in the opposite extremes if a sufficiently great range of speed or load be investigated. Otherwise the




L = Lanchester.
P = Parallel type.

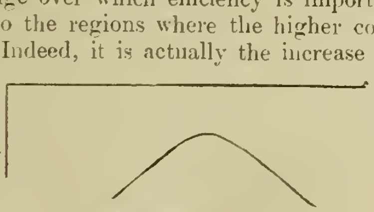
Worm Gear.—Fig. 2.

approximate constancy of the angle or coefficient of friction may be taken as established. It is evident that the constant condition corresponds to the minimum value of coefficient, or conversely the maximum of efficiency. In the nature of things, where A is a function of B, A is approximately constant in respect of B when A is a maximum and when A is a minimum. This is as commonly expressed in the equation for maximum or minimum value as $dA/dB = 0$. Thus, there is nothing extraordinary in the fact as stated.



Worm Gear.—Fig. 3a.

Its importance from the point of view of the theory of worm gear efficiency lies in the fact that the maximum is rarely, if ever, found to be a "peak," it is rather a "table land," and is of the type shown in Fig. 3a, rather than the type shown in Fig. 3b. It is a further point of importance in connection with the theory of worm gear that the practical range of usage over which efficiency is important does not carry us into the regions where the higher coefficients are met with. Indeed, it is actually the increase of the coeffi-



Worm Gear.—Fig. 3b.

cient and falling off in the efficiency under excessive load that determines sharply the maximum load limit to which any given pair of gears may be subjected, for a very moderate increase in coefficient above its normal "least value" results in, or is evidence of, the partial breakdown or rupture of the lubrication film and the disintegration of the gear. This is the case whether it be of the Lanchester or parallel type; in fact, the increase of the coefficient under heavy loading is the first sign of incipient lubrication failure, and so the point of fall in the efficiency curve under heavy loading may be taken as an invariable indication, in the comparison of any two pairs of gear, of their relative higher load limits.

In engineering practice we are accustomed to meet problems in which the coefficient of friction is legitimately treated as constant; in all these problems certain actual variations exist, but the underlying fact is so nearly true that the basis theory is correctly founded on the assumption of a constant coefficient of friction, and such changes as are met with are considered as variations from this constant value rather than in relation to the zero. The tests published in the author's previous paper fully establish the fact that power transmission worm gear comes legitimately into the group of such problems, though it was by no means certain prior to the paper that this was the case. If such results as those of Professor Kennerson were true, we should not be justified in basing any arguments on the constancy of the frictional coefficient, and the foundation of the theory of worm gear efficiency would consequently become far more complex and difficult than is actually the case.

*(To be continued).*

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## ELECTRICAL RESISTANCES AND THEIR USES.

By F. Ashton.

Although it is, of course, essential that the resistance of most electrical circuits should be as low as possible, artificial resistances of various kinds are employed very extensively. In power-houses and in sub-stations, and on consumers' premises, resistances are utilised for many purposes. For motor starting, speed and voltage regulation, testing sets, ammeter shunts, and so forth, use must be made of materials that offer appreciable opposition to the flow of an electric current. The standard resistance, known as the standard ohm, is a column of mercury of specified length and cross section, but such resistances are seldom if ever used outside testing and experimental laboratories. There are, however, secondary standards composed of high resistance wires which can be handled much more conveniently than columns of mercury. In resistances boxes for testing purposes, wires are wound non-inductively upon bobbins and mounted inside the boxes. The ends of the coils are connected to separate brass blocks, arranged in such a way that any resistance coil can be cut out of circuit by inserting metal plugs between the blocks. With resistances for precision testing, however, the writer does not propose to deal, for from the point of view of power plant engineers, other forms of resistances are more important. Electrical precision testing, though distinctly fascinating, is a branch of electrical engineering quite distinct from power plant operation, and in large generating stations, at any rate, it is carried out in a separate department and by a special testing staff. Engineers who run power plants are more interested in resistances for starting motors, resistances for voltage regulation, resistances for use in conjunction with instruments such as ammeters on the switchboard and resistances forming artificial loads.

### Ammeter Shunts.

Moving coil switchboard instruments, such as ammeters, are provided with so-called shunts, which carry the main current to be measured. These shunts offer a small amount of resistance to the passage of the current and the resultant pressure drop across the shunt serves for sending a small current through the coil of the ammeter, and since the pressure drop is proportional to the main current, the small current passing through the instrument increases with the main current, and the needle of the instrument moves over the scale. Suppose, for instance, that the resistance of a shunt be ·001 ohm, and that the instrument has ·050 volt applied to its terminals, obviously, from Ohm's law, the current in the circuit will be

$$\frac{\cdot 050}{\cdot 001} = 50 \text{ amperes.}$$

The instrument, which is really a milli-voltmeter, is calibrated together with its shunt, and the scale is designed to read directly in amperes instead of in millivolts. In the case of ammeters for currents up to 25 amperes, but not over, the shunt may be placed inside the instrument case so as to make the instrument self-contained. Ammeters for heavy currents, however, have separate shunts which are mounted in any convenient position, and they are connected to the instrument by means of flexible wires. With these wires the instruments are, of course, calibrated and on no account must the length of the wires be altered after the instrument and its shunt have left the test room. Ammeter shunts are made of strips of manganin, German silver or other material of high specific resistance, and low temperature coefficient. The strips are sweated into heavy brass blocks, each block having two terminals, one for the main cable and one for the ammeter lead. Ammeter shunts have low resistance, for, being in series with the circuit in which the current to be measured is flowing, a high resistance would involve considerable waste. On switchboards, various other resistances are usually employed in conjunction with the electrical instruments. Resistances known as multipliers are frequently connected in series with voltmeters to cut down the current flowing in the coils, and by altering the value of the resistance in the multiplier the range of a given voltmeter can be changed within wide limits.

### Starting and Regulating Resistances.

There are many patented forms of resistances or rheostats for starting and regulating electric motors, so many, in fact, that it is impossible to deal with them all in a short article. The orthodox form of starting resistance for continuous-current motors consists of a number of contacts mounted on a slate or similar base. To these contacts resistance coils or grids are connected, and a switch arm is arranged to have over these contacts, and gradually cut the coils out of circuit. Two automatic attachments are usually fitted to these starters. One is a "no-voltage-release coil" which in the event of the supply failing allows the starting handle to fly back over the contacts, so that all the resistance is inserted in the circuit, ready for starting the motor again when the supply is renewed. In the absence of a "no-voltage-release" the handle of the starting resistance would, of course, remain in the running position, and on the supply being re-established the low resistance of the stationary armature would produce a short-circuit. The no-voltage-release attachment consists of a small electro-magnet, which is connected across the terminals of the motor. It is placed just behind the last resistance contact, so that when all the resistance has been cut out of circuit its magnetism holds the starter handle in position against the action of a spring. But in the event of the supply failing, the hold on coil loses its magnetism, and the starting handle flies back into the off position. The second attachment is an overload release, which causes the starter handle to return to the off position in the event of the motor being overloaded. It consists of another electro-magnet, but in this case the winding is in series with the motor. This electro-magnet is capable of attracting a small iron armature, like the armature of an electric bell, and when attraction occurs, as the result of excessive current passing round the overload coil, the armature short-circuits

the no-volt release bobbin, with the result that the bobbin is relieved of its current, and the starter handle moves back to the off position in exactly the same way as when the supply fails. The starter handle cannot be left in an intermediate position, owing to the action of the spring. Starters of this kind are not capable of carrying the current for any length of time: hence, they are designed so that if the operator lets go of the handle in the middle of the starting period the starting arm immediately flies back to the off position, and opens the main circuit. But, quite apart from ordinary starters being incapable of carrying the main current for any length of time, resistance left in the main circuit of a motor involves considerable waste. Small motors, such as fan motors, are, it is true, frequently regulated in this way, but the speed of large motors is usually regulated by means of a resistance in the field circuit. Such resistances only carry a few amperes; consequently the loss of energy involved is inappreciable. Similar regulating resistances are also used for controlling the voltage of electric generators.

### Starting Resistances for Large Motors.

For large motors involving heavy starting currents, face-plate starters, as described above, are unsuitable, owing to the difficulty of preventing arcing at the contacts. Auxiliary or arcing contacts that can readily be renewed may minimise the difficulty, but for heavy currents, starters with arms moving over rows of contacts leave a good deal to be desired. An alternative arrangement, which is far preferable when the starting current is heavy, is to cut the resistance out of circuit by a number of lever switches. An American starter, designed and constructed upon these lines, works very satisfactorily. It is designed so that the individual switches must be closed in the correct order. Moreover, it is fitted with a "no-volt-release coil," and in the event of the voltage failing all the switches open.

### The Use of Contactors.

For starting motors, extensive use is now made of contactors similar to those employed upon electric trains. The switches which cut out the resistance are actuated by electromagnets, which are energised by a master switch. Elevator motors are generally started in this way, and within recent years the system has been applied to many other kinds of service. The system, which lends itself to push-button control, is classed as an electrically-operated system. Electrically-operated starters differ from other starters in that instead of resistance being cut out of circuit by hand, it is cut out electrically by contactors, or by an arm moved over contacts by a solenoid. Electrically-controlled starting resistances are utilised when it is desired to start motors from a distance, and when it is desired to accelerate the motor independently of the operator's will. Men devoid of electrical training are apt to accelerate motors too rapidly, and under such conditions automatic control is a distinct advantage. With the details of automatic-control systems the writer does not propose to deal on the present occasion, for the subject is a somewhat broad one. It must suffice to say that by pressing a button, or by closing a small switch, the motor starts up on its own accord, and without drawing an excessive current. Frequently the small control switch is actuated automatically, as, for instance, by a float in a water-tank. A pump motor controlled in this way will maintain a constant water-level in the tank.

### Drum Controllers.

Upon the subject of starting resistances an enormous amount might be written. Besides the starters referred to, there are, of course, various kinds of controllers, such as drum controllers, as used on electric trains and tramcars. Drum controllers are also employed very largely for controlling the motors that operate machine tools. When an electric motor is started and stopped only a few times during the day, and is intended to run at constant speed, an ordinary faceplate starter will serve, provided only small and medium currents have to be dealt with. But when a motor has to be started and stopped, and have its speed varied at frequent intervals, as with motors driving some kinds of machine tools, the problem is altogether different, and something more robust than an ordinary face-plate starter is requisite. Drum controllers, having the contacts which cut out the resistance, mounted on a revolving are are employed extensively for such kind of service. An ordinary machine tool controller has usually to perform three duties, (*a*) to start the motor, (*b*) to reverse the motor, and (*c*) to vary the speed. Though the connections for a drum controller capable of performing all these operations are apt to appear a little complicated, this, of course, is a matter that does not concern the machinist. All he has to do is to turn the handle one way or the other, and the controller does the rest. The motor, which may be shunt or compound wound, is started with a certain amount of resistance in the main circuit, and the controller cuts this resistance out of circuit as the motor gains speed. If a wide speed variation is desired, it may be obtained by inserting a certain amount of resistance in the main circuit, as well as in the field circuit. Resistance in the field circuit of a motor increases the speed, whilst resistance in the main circuit reduces it. But, as pointed out previously, resistance in the main circuit of a motor is wasteful, and whenever possible, all the speed regulation should be obtained by connecting resistance in the field circuit. To reverse a motor the armature leads are interchanged, whilst the direction of the current in the field magnets remains the same under all conditions. Drum controllers are often fitted with a small drum for reversing, whilst the main drum, which is operated by the main handle, serves for starting and speed regulation.

*(To be continued.)*

## ENGINEERING PRECAUTIONS IN RADIO INSTALLATIONS.

By Robert H. Marriott.

*(Continued from page 436.)*

In the United States in 1901, in order to prevent induction in mast guys, these guys were made of rope. In 1902, owing to the stretching and contraction of the rope in dry and wet weather, the writer substituted steel guys with rope blocks and falls at the bottom of the guys to serve as both insulators and as means for adjusting the guys. About this time, or before, others used wooden strain insulators in the guys. On some occasions both the rope insulators and the wooden strain insulators were burned by current leakage between the guys and ground. Even on shipboard attempts were made at times to insulate guys and stays between masts. However, owing to the difficulty of providing insulation which would not leak, the principle of thoroughly grounding the stays and guys was adopted. Stays and guys and other metallic conductors, such as handrails, occasionally discharged to passengers, causing considerable excitement and fear on the part of some steamship companies that passengers might be electrocuted. The remedy used for this was thoroughly to ground stays

and guys, etc. Even the metal whistle cords on vessels occasionally discharged to damp woodwork, etc., and often a person who tried to manipulate the whistle received a shock. These were grounded by using flexible wire ground connection. Steel beams, steam pipes, long bolts, anchor chains, and other conducting materials, on vessels, have been known to spark to ground or to other conductors. Conduits containing electrical wiring have apparently discharged to the ends of wiring where the conduits were not grounded. Metal roofs in the vicinity of land stations, and metal roofs of wharves, have discharged to ground, causing charring of the wood to such an extent that fear of fire resulted.

On account of sparking on their vessels, one line had a tendency to accuse the radio apparatus of being responsible for nearly anything that went wrong with the electrical circuits on the vessel, even going so far as to say that the radio currents went down through the vessel and into the water condenser of the engine, and caused electrolysis to such an extent that the water condenser had to be replaced!

On a line where the vessels were almost entirely constructed of wood, sparking, charring, and injured apparatus resulted at a number of points. The mast stays were wrapped with houseline and passed through thimbles connected to the hull of the vessel, thereby insulating the mast stay from the hull of the vessel by the houseline. This houseline was set on fire and burned away, due to the sparking between the mast stays and the hull of the vessel *via* the thimble. On these vessels the mast head lights, running lights, and port and starboard lights, were connected to the pilot house signal light switchboard by means of rubber-covered twin conductors without metal covering. All of these signal light circuits were burned out from time to time, due to sparking across the lines or between the lines and ground. Annunciator circuits and call bell circuits throughout the vessels discharged to metal portions of the ship, and in some cases caused slight charring of woodwork.

On one occasion a steamship company asked that their vessel be gone over with a view to preventing any possibility of igniting explosives which they expected to carry. In this case it was recommended that all metallic conductors in the hold and in the vicinity of the hold be thoroughly grounded and electrically connected together, even the short metal ladders and supports which extended from one deck to another.

Three instances are recalled of wooden masts set on fire due to the discharging of guys to each other through the woodwork of the mast. In two of the cases the masts were burned off several feet from the top. In these cases the guys were 50 ft. (15 metres) or more from the antennæ.

It has been found that radio currents were induced in the metallic paint on masts, and on some occasions the metal paint was removed and a portion of the mast varnished. Some years ago it was the rule to make all radio masts of wood. Also wooden top masts have been required on shipboard because of the radio apparatus.

Regarding the ability of sparks to start fire, that obviously depends on the heat developed by the spark and the heat required by the combustible material. Very small sparks are almost universally used for igniting gas or gasoline vapour in gas engines, and it is quite possible that similar gas might be ignited by equally small or smaller sparks on shipboard or at other points near radio stations. Sparks developed by radio transmitters might be capable of igniting oils such as are found, for example, in the paint lockers on vessels. Theoretically, radio might cause distress conditions by setting the ship on fire and then relieve these conditions by bringing aid!

While the paper has been confined practically entirely to personal observations, the conclusion is not to be drawn that the damaging results always occur. The instances mentioned practically cover all the cases noted during a period of about 15 years' use of radio frequency circuits, including radio frequency apparatus operated under a large variety of relations to adjacent conductors at stations on both coasts of the United States, at numerous points inland, and on the vessels of several nations.

Protection against radio frequency currents of dangerous potential being induced in low potential direct current of audio frequency circuits may be brought about to a considerable extent by taking advantage of the ways in which radio frequency currents differ from direct current and audio frequency currents.

Condensers of small capacity impede radio frequency currents very much less than audio frequency currents (that is, radio frequency currents usually find an easy path through small condensers, while practically no 60-cycle current or direct current will flow through small condensers). For practical purposes small condensers may be assumed to be good conductors for radio frequency currents and insulators for direct current and alternating current having frequencies in the neighbourhood of 30 to 500 cycles.

Condensers have been installed in series with fuses to ground. This practice is objectionable because if the fuses burn out the lines are left unprotected at a time when such protection is most likely to be needed, and unless the fuses are in some way arranged to notify some person, it is quite probable that they will not be known to have burned out until after damage occurs to the low-tension circuits.

Mica condensers in which lead-foil was used have been found to provide automatic self-fusing devices without destroying the service ability of the condenser; for example, when a sheet of mica punctured making a small hole, the lead-foil melted away from around the hole until the arc was extinguished and the condenser then operated as before.

Radio frequency currents do not penetrate very far into the conductor, or flow to any great extent in a conductor, when that conductor is screened by a concentric conductor such that the radio frequency may flow in the concentric conductor; thus, for example, very little if any radio frequency current will be induced in a pair of rubber-covered copper wires enclosed in an iron conduit, where the iron conduit is grounded at intervals.

Low potential circuits have often been protected from radio frequency potentials by grounding the low-potential circuits through high resistance rods made up of carbon and clay; and in some cases by using incandescent lamps between the conductors and ground. The writer has always considered this an objectionable practice, because to some extent it grounds the low-potential circuits, which are usually better ungrounded. Also, according to the experience of the writer, these high resistance grounds have apparently offered, as a rule, greater impedance to the radio frequency currents than small condensers offered. Slate switchboards sometimes served as protectors to low-frequency circuits because their resistance was sufficiently low to allow them to act much as the high resistance protective rods.

(*To be continued.*)

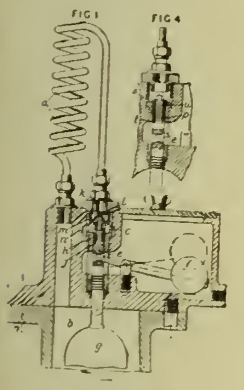
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

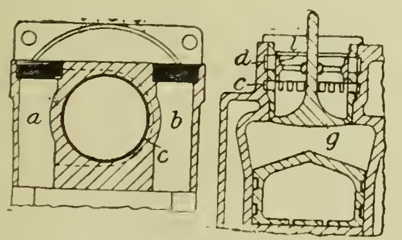
## ABSTRACTS OF SPECIFICATIONS.

### SEPARATING AIR FROM LIQUIDS.

107,030.—W. H. WALKER, 108, Fenchurch Street, London.—May 10th, 1916.—A condenser is arranged between the gas-accumulating chamber and the valved exit for discharging the gas, so that any vapour which would otherwise escape with the gas is condensed and returned to the accumulating-chamber. An additional valve is preferably employed in conjunction with the air exit valve. The apparatus is suitable for boiler feeds and the like. The air accumulates in the chamber $b$ which is connected through a condenser $a$ with a valve chamber $c$. A valve piston $e$ having a central passage $h$ and lateral ports $j$ is operated in the known manner by a float $g$ and counterweight $f$. The additional valve is constituted by a "thimble" $m$ with a conical port $l$ adapted to close the upper opening $k$ of the passage $h$. As the valve piston $e$ descends, the thimble $m$ descends with it until arrested by an abutment $n$, when the piston $e$ descends, alone and opens both valves, the ports $j$ being then open to the atmosphere. Alternatively a sleeve $p$ having a flange $s$ may slide upon the reduced upper portion of the piston $e$, passages $u$ being provided in the reduced part to serve as the channel $h$: when the piston descends, the sleeve $p$ descends with it until it is stopped by an abutment when the piston descends alone and creates an annular port $t$ between the lower end of the sleeve $p$ and its seating on the piston $e$. It is stated that the valves may be modified so as to open on the ascent of the piston $e$.



Patent 107,030.



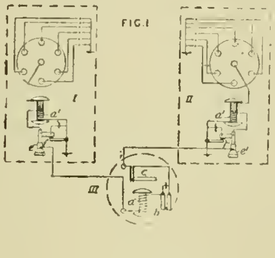
Patent 107,039.

### INTERNAL-COMBUSTION ENGINES.

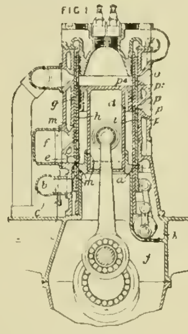
107,039.—E. W. BOWEN, 12, The Avenue, Bedford Park, and T. L. DAVIES, 1, Quernmore Road, Finsbury Park, both in London.—June 8th, 1916.—In two-stroke cycle engines, scavenging air and combustible mixture are passed into annular spaces $c$, $d$, respectively, in the cylinder head and are admitted successively into the cylinder by the movement of the supplementary valve $l$ mounted on the spindle of the inlet valve $g$. Air is supplied by a pump driven directly or indirectly from the engine to a reservoir, from which it passes through a passage partly divided into two passages to the cylinder. One passage contains a Venturi or like tube, into which projects a jet connected to the float chamber of a carburettor. The passages communicate with passages $a$, $b$ which pass over the cylinders, and are connected to the annular spaces $c$, $d$, respectively. A flap valve may be placed at the junction of the passages in order to vary the quantity of air passing the jet. Instead of the pump, a rotary blower or the crank case may be used for supplying air, and the reservoir may be dispensed with. In a modification, a second piston or sleeve working within the cylinder and actuated by the crankshaft may uncover ports in the cylinder wall for admitting scavenging air and combustible mixture.

### INTERNAL-COMBUSTION ENGINES.

107,048.—SIEMENS BROS. AND CO., Caxton House, Tothill Street, Westminster, and H. W. F. IRELAND, 80, Wellington Road, Charlton, Kent. June 10th, 1916. At starting, current is supplied to the primaries of two or more high-tension magnetos by means of a single auxiliary source, such as a low-tension magneto or a coil and battery arrangement. The armature winding $a$ of the auxiliary magneto III is connected in series with the interrupter $b$, a hand-operated or automatic switch $c$, closed only when the armature $a$ is rotating, and with the interrupters $e$, $e1$ and primaries $a1$ of the service magnetos I, II, the free ends of the windings $a1$ being earthed. The interrupter contacts $f$, $f1$ are geared to act alternately. The interrupter $b$ and winding $a$ may be in parallel. When more than two service magnetos are employed, one terminal of the winding $a$ is earthed and the service primaries are connected in parallel to the other terminal. Each service magneto is in this case provided with a distributor, the tongue of which is actuated in synchronism with the contact breaker of the corresponding magneto. If the interrupter be sufficiently retarded, the distributor acts as the timing device; if it be advanced to an extreme position, the whole starting device is inoperative.



Patent 107,048.



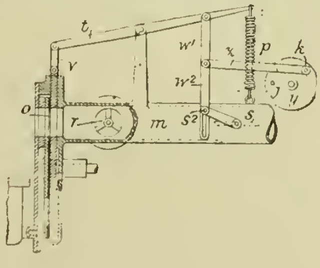
Patent 107,053.

### INTERNAL-COMBUSTION ENGINES.

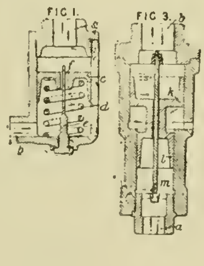
107,053.—ORVILLE, T. L. R. D', 241, Addison Way, Golders Green, London.—June 13th, 1916.—In four-stroke engines working with supercharge and having a sleeve valve or valves co-axial with the cylinder, two exhaust ports, $o$ $p$ are provided which are uncovered simultaneously, and the lower of which is not governed by the piston edge. In the form shown, the exhaust ports $o$, $p$ are controlled by two sleeve valves $h$, $i$, each of which is provided with a pair of ports $p^1$, $p^4$ and $p^2$, $p^3$, respectively, the exhaust occurring when the ports $o$, $p^3$, $p^4$ and $p$, $p^1$, $p^2$ are in alignment. The piston and cylinder $g$ are made of aluminium alloy, and the sleeves $h$, $i$ of harder metal, such as cast iron, gun-metal, or bronze. The supercharge is drawn from the carburettor by a pump $d$ through a pipe $b$ and ports $a$, and is forced through a delivery port $e$ to the receiver $f$. The pipe $b$ is provided with a throttle $c$, and a main throttle (not shown) also is provided on the carburettor delivery pipe which regulates the supply of mixture to both cylinder $g$ and pump $d$ simultaneously. Rings $m$ are provided in the cylinder wall and crank-case extension to prevent leakage of the compressed mixture. A well $k$ is provided in the top of the crank-case $j$ to receive any mixture which may leak along the cylinder walls and sleeves.

### INTERNAL-COMBUSTION ENGINES.

107,056.—G. E. PUGH, 28, Stapleton Road, Upper Tooting, Surrey.—June 14th, 1916.—The carburettor described in the parent specification is provided with a throttle valve $s$ and an automatic secondary-air valve $r$ in the induction passage $m$, and with means for controlling the shutter $o$ both synchronously with and independently of the throttle valve $s$. The shutter $o$ may comprise two parallel plates, one connected by links to the throttle valve and the other controlled by separate means; or, as shown in Fig. 3, the shutter $o$ is connected by links $v$, $w^1$, $w^2$, to the throttle valve $s$, a link $z$ and crank-pins $k$, $j$ on disc $y$ being provided to enable the shutter $o$ to be raised or lowered independently of the throttle valve. The lower end of the link $w^2$ is slotted and a spring $n$ tends to keep the upper end of the slot and the pin $s^2$ in contact.



Patent 107,056.



Patent 107,058.

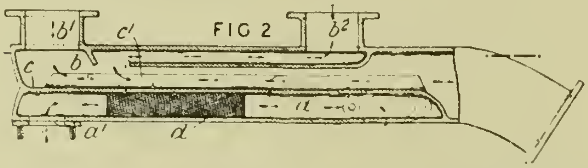
### HYDRAULIC TRANSMISSION OF POWER.

107,058. G. CONSTANTINESCO, Haddon Engineering Works, Honeypot Lane, Alperton, Middlesex, and W. HADDON, 132, Salisbury Square, Fleet Street, London. June 14th, 1916.—In an hydraulic transmission system of the kind described in Specifications 9029/13 and 12438/14, means are provided for cutting off the supply of energy from an apparatus situated on a branch pipe from the main transmission pipe, by the regulation of a leak situated on the branch line. In the apparatus shown in Fig. 1, the main transmission pipe is connected at $a$ and the branch pipe at $b$. An oscillating piston $c$ with a central opening is controlled by a spring $d$. A fixed spindle $e$ has its upper part reduced in diameter at $f$. If the mean pressure in the branch line is caused to drop, the piston $c$ is forced on to the spindle $e$ and cuts off the branch pipe. The piston may be replaced by a flexible diaphragm, and in both cases a small leak is normally allowed past the spindle $e$. In a modification, Fig. 3, the main pipe is

connected at $a$ and the branch pipe at $b$, a differential piston $k$, $l$ being interposed between the two. The piston slides over a rod $m$ with a small clearance. If the leakage from the branch pipe is stopped by a valve, or if it is made excessive, the mean pressure increases or decreases on the branch line side, and the piston is pressed to one end or other of its stroke, and its oscillations thus stopped. In a further modification, the middle part of the rod $m$ is of smaller diameter, and the apparatus may be used with tools such as rock drills, in which considerable leakage is normally allowed. If the leak in the branch pipe is increased, the piston is forced upward on to the increased diameter of the rod, which cuts off the supply. If the leak from the branch pipe is stopped, the piston is forced downwards on to the increased diameter of the rod. Specifications 4349/15 and 4350/15 also are referred to.

### INTERNAL-COMBUSTION ENGINES.

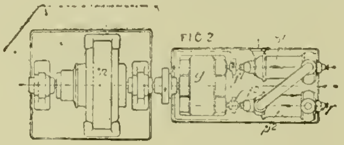
107,098.—W. H. Bradburn, "Long Knowle," Wednesfield, Wolverhampton, and A. Cox, "Harlech," Warwick Road, Olton, near Birmingham.—July 14th, 1916.—In an exhaust-heated vaporiser comprising a vaporising chamber $a$ and a heating chamber $b$, the




exhaust gases entering by the inlets $b^1$, $b^2$ impinge on that part of the partition $c$ which is immediately opposite to the mixture inlet $a^1$. The chamber $a$ is packed with wire-gauze $d$ or small tubes. Webs $c^1$ are formed on the partition $c$. Specification 7171/12 is referred to.

### TURBINE PUMPS.

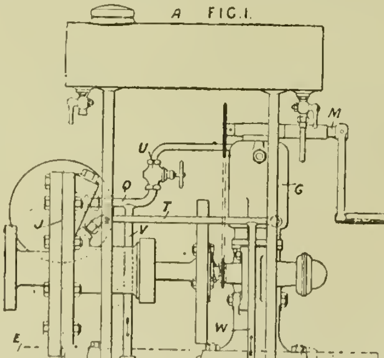
107,105.—B. Wiesengrund, West Drayton, Middlesex.—July 28th, 1916.—The two units $p^1$, $p^2$ of a centrifugal or turbine pump connected in series or parellel are secured by flexibe couplings $f^1$,



$f^2$ or otherwise to shafts carrying pinions meshing with the same wheel of a speed-increasing or speed-reducing gear $g$ directly coupled to the driving motor $m$.

### CENTRIFUGAL PUMPS.

107,113.—Villiers Engineering Co. and G. Funck, Villiers Works, Blackenhall, Wolverhampton.—August 25th, 1916.—Relates to portable pumping plant comprising an internal-combustion engine and a centrifugal pump, suitable for pumping water from ponds, trenches, etc. The engine G is directly coupled to the pump J, and the fuel tank A is located over the engine and pump to form a protective canopy. The exhaust pipe of the engine may lead into the hollow bed-plate C, or a separate silencer may be




used. The bed-plate has a water-jacket D, which is included in a by-pass V W of the pipe system Q, T conducting water from the delivery side of the pump through the engine jacket back to the suction side of the pump. A valve U which cannot be completely closed, is provided in the pipe Q. The apparatus has handles E, which may have extensions F adapted to enter the ground. A hand-operated starting-shaft M may be provided, or a foot-operated starter used instead.

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THE

# Industrial Engineer.

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# EDITORIAL.

## COAL GAS FOR MOTOR VEHICLES.

The shortage of petrol for general purposes of trade mainly outside war services has brought into prominence the old tag of "necessity is the mother of invention," which has been so often exemplified during the war in almost all directions of activity. Thus, petrol shortage in the first place mainly drove motor vehicle owners to adopt petrol substitutes such as paraffin and the other coarser or heavier spirits as fuel for their engines, slight adjustments in carburettors and the adoption of some form of preliminary heating being employed to enable the heavier fuel to be employed with success. A small quantity of petrol was often used for starting purposes, after which the heavier spirit was brought into play. These methods seem likely to succumb, in part at least, to coal gas, which is being increasingly used in motor vehicle engines for propulsive purposes. The general method of application of this fuel is crude in the extreme. Its first use seems to have been in connection with motor 'buses and commercial vans, on the top of which it is stored in flexible bags. The latter are so large as each to represent a decent sort of irregular balloon, a not very inspiring sight to the engineer in the matter of power application. Its use cannot be regarded as anything but a makeshift, yet the method serves its purpose of enabling a 'bus or van to be run some 20 miles or so before re-charging is necessary, and at considerably less expense than petrol or its spirit substitutes. In 'bus services the large gas bag decreases passenger accommodation by something like 50 per cent, which has to be taken into account on the debit side. In general, the job is unsatisfactory. Various attempts are being made to supersede the gas-bag arrangement. The apparent difficulty is to obtain metal cylinders as containers in which the gas can be compressed to some extent into smaller compass. To this end old coal-gas cylinders, such as are used for train gas-lighting services, are being employed with some success, whilst in others cylinders of a built-up type in light materials are being used. There are, however, limits to the useful compression of coal gas into small space. We believe that it is not worth while or practicable beyond 500 lbs. per square inch, at which pressure some of the constituent elements of the gas liquefy and do not again resolve themselves on pressure reduction. It is, therefore, doubtful if much real relief will be found in this direction.

**The Supply of Coal Gas.**

In another part of this impression attention is called by one of our correspondents to the method of coal gas supply in the sense that the pipe connections employed at various charging stations vary in size. This, of course, should not be. He rightly suggests the employment of standard connections, the 2-in. gas size being preferred. This has the approval of the gas authorities in Manchester. It is a sensible and, moreover, practical suggestion, and one which there ought to be no difficulty in adopting. The size, as a matter of fact, does not matter so long as a universal standard is used. The time to do that is now, before the movement becomes extensive and expensive. The further suggestion that gas prices for motor purposes should be per 100 cubic feet seems also a very reasonable proposition. It would also be advisable to agree upon a fixed universal price for the gas, but we are afraid this is

more than can be expected. We do not get it now for ordinary gas-engine work and lighting, and it is hardly likely the municipal authorities and private gas companies will alter their present methods.

## Trade Items, Notes, &c.

A New Graving Dock.—The new graving dock at Point Levis, Quebec, will be finished shortly. It will be the largest dry dock in the world, being 1,150 ft. long, 120 ft. wide, and 45 ft. deep, making it 10 ft. deeper than the next largest, at Boston, Mass., and 130 ft. longer than the Gladstone Dock at Liverpool, which, however, is 1 ft. deeper.

New Works Extension.—Messrs. Bromell Patents Co. Ltd., the manufacturers of "Simplex" specialities for power plants, have just completed the building of the first section of their new works at Glasgow, which is well lighted, and equipped with new machinery and electric drive. The extension will facilitate the quick execution of orders—a great convenience in the case of ships which may have only a brief stay in port.

Brown Coal in Russia.—Investigations by the Special Fuel Conference have led to the discovery of a bed of brown coal, about 25 feet thick, near Elizabetgrad, South Russia. Working has commenced, and the August output is expected to make 100,000 poods. When fully developed, a production of 500,000 poods per month is anticipated. Brown coal beds in the Governments of Cherson, Kieff, and Volhynia are to be investigated in the near future.

World's Production of Copper.—The world's production of copper in 1916 was 1,396,600 tons, as compared with 1,061,300 tons in 1915, an increase of 335,600 tons. The 1914 output was 923,909 tons, and that of 1913 was 1,066,000 tons. Of the 1916 total 880,880 tons are credited to the United States, the output of which in 1913 was 556,000 tons. The Geological Survey of that country has estimated the production of smelter copper for 1916 at 1,927,850,848 lbs., or 860,647 gross tons. Next in importance ranks Japan with 90,000 tons in 1916, followed by Chili with 66,500 tons, and Mexico with 55,000 tons.

Under the direction of the Japanese Government Steel Foundry at Yawata, Kiushu, a steel foundry will shortly be established on a site on the Yangtze Valley, not far from the Tayeh iron mine, from which the Government Steel Foundry is obtaining a supply of iron ore, in accordance with the agreement entered into between the Japanese and Chinese authorities several years ago. A tract of land has been purchased by the Japanese authorities at a point near the Tayeh mine, and the engineering work is now going on there under the charge of Dr. Oshima and other experts from Japan.

Water-Power Development in France.—According to "L'Industrie Electrique," the war has had a remarkable effect in stimulating the development of water-power in France. The water-falls in the French Alps are being utilised to an ever-increasing extent, and power-houses of a total capacity of 40,000 H.P. are in course of erection. Electro-metallurgical and electro-chemical work in their vicinity has been greatly developed, and it is calculated that if all these sources of power were fully exploited as much as 15 billion kilowatts per annum would be available.

Industrial Resources of the Firth of Forth.—A movement has been inaugurated by the Provosts of Leith, Kirkcaldy, and Grangemouth for furthering the development of the industrial resources of the Firth of Forth district. A conference has been held at which it was resolved to bring under the notice of the Government the facilities for docking, repairing, ship repairing, etc., which exist at, or are adjacent to, the different seaports on the Firth, and arrangements were made to prepare a statement showing the present facilities of the ports and the developments which might be made, or might be expected to take place, in the near future.

Brown Coal in Victoria. A committee of the Institute of Victorian Industries, which has been inquiring into the utilisation of the brown coal deposits in Victoria has recommended that immediate steps be taken to obtain estimates of the cost of opening up workings at Morwell, and of equipping them to produce coal for a 50,000 kw. power station and to supply 120 tons of briquettes a day; of erecting 50,000 kw. plant at Morwell and similar plant at Altona, with transmission line in each case; and of establishing a briquetting plant having initially a single press unit of 60 tons capacity a day, but capable of expansion to six or seven units.

Ministry of Munitions Appointments.—The following appointments have been approved by the Minister of Munitions: Col. W. C. Wright to be Controller of Iron and Steel Production, in the place of Sir John Hunter, K.B.E., appointed member of Council; Major A. Corbett to be Controller of Explosives Supply, in place of Sir Keith Price, appointed member of Council; Major J. H. M. Greenly to be Assistant Controller of Administration in the Inspection Department, in place of Sir H. Ross Skinner; Sir Leonard W. Llewelyn, K.B.E., Deputy Director-General of Materials Supply, will in future be known as Controller of Non-Ferrous Materials Supply.

Junior Institution of Engineers.—The Junior Institution of Engineers has instituted a "Cadet Associate Membership," whereby engineering pupils in works or college (day or evening students) may be registered for a nominal yearly fee of 5s. It is open to youths of 15 years and over who are still undergoing training, and who, as certified by a principal of a technical college or head of department of an engineering works, are making satisfactory progress in the development of their abilities as engineer pupils. The registration as a Cadet Associate Member of the J.I.E. is for one year only, and renewals can only be accepted when satisfactory progress and development is vouched for by a responsible authority under whom the applicant is serving. The Institution undertakes certain duties in regard to these cadets, which are set forth in a pamphlet, which may be obtained upon application to the Secretary, 39, Victoria Street, Westminster, S.W. 1.

Radio-Telephones for Load Dispatching.—At the present time the United States Government has forbidden the use of wireless telegraph and telephone equipment, except under its supervision, but it is stated in the "Electrical World" that the Public Service Co. in Northern Illinois is already considering the use of radio-telephone connection for load-dispatching in the future. Two radio-telephone sets are being installed between sections 150 miles apart, and are being tested with the co-operation of the United States Navy Department. Should the units prove satisfactory, one will probably be installed in the system operator's office at the new generating station at Joliet (Ill.), and the other at the company's generating station at Blue Water Island. This connection will facilitate load dispatching in emergencies caused by failure of the company's private metallic-circuit line. Ultimately the system will be applied to other distribution centres. The use of radio-telephones was preferred to wireless telegraphy on the ground that it avoids a knowledge of the Morse Code, and also enables messages to be transmitted with greater speed.

Filling Cracks in Cylinder Water-Jackets.—A simple method of filling up cracks in the water-jackets of motor-car engines which is often adopted in France consists in making use of a liquid solution in which advantage is taken of the property possessed by copper salt to deposit their metallic contents when in contact with iron. To fill up a crack in the water-jacket, all that is necessary is to fix the cylinder vertically in a bath or tank; plug up the lower water outlet in the jacket with a cork; then fill the jacket through the upper inlet with a sufficiently concentrated solution of sulphate of copper, which will at once commence to leak away through the crack or cracks and collect in the bath. The liquid should be scooped up as it collects and repoured into the water-jacket; the leakage will be quickly reduced to a slight "weeping" at the crack. When this weeping period has been reached, stop up the upper inlet with a cork in which a bicycle tyre valve has been fitted, and by means of a tyre inflator force air into the jacket. At first the degree of weeping will increase, but it will gradually disappear, and become almost colourless instead of a bluey tint, the repair of the crack then being completed.

## NOTES ON THE CONSTRUCTION OF TURBINE-PUMPS.

By Alan E. L. Chorlton.

(*Continued from page 454.*)

From a works construction point of view, "ring casings," Fig. 1 (*a* and *b*), are the most economical, and in practice give high efficiency. In the form similar to that shown in Fig. 12, the Author some years ago was able to mould and cast ring-casings without cores, machine moulding being adopted, and the cost per chamber coming out at a very low rate.

For "cylindrical" casings, Fig. 2 (*a* and *b*), a complete pattern is required for each size and variation in number of chambers. Its accessibility, how-

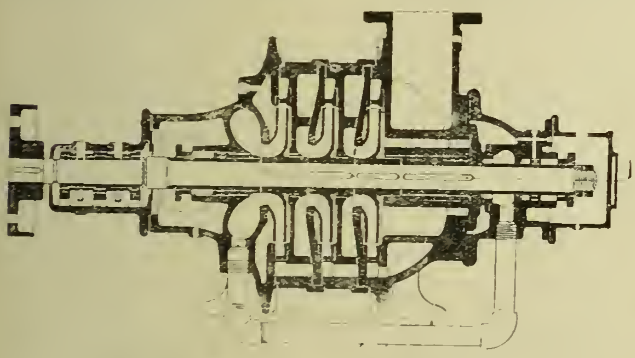


Fig. 12.—Modern Form of Turbine Pump.

ever, and ease of dismantling is sometimes considered to be greater than with the "ring" type, though this is, to a certain extent, a matter of opinion. A great drawback to casings containing separate cells is that, on account of the sliding fit between the intermediate pieces and casing, an unknown amount of leakage constantly takes place between the cells. With a "ring" type of pump, leakage is instantly detected and can be remedied. As a commercial proposition the author unhesitatingly favours the divided or "ring" type of casing, and, when pro-

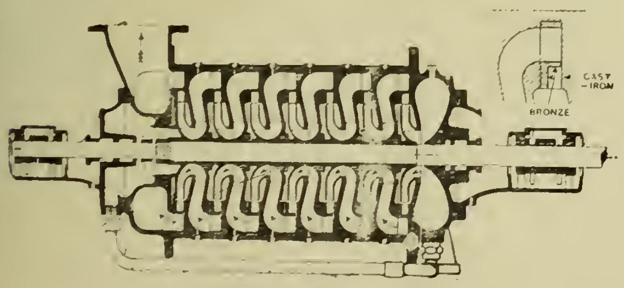
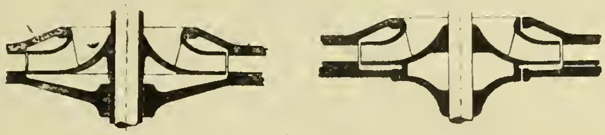



Fig. 13. (Farcot.)

perly carried out, has met no difficulty with it in practice.

Before leaving this part of the subject, a word about the finish of guide-passage surfaces is necessary. For best efficiency the throat of the passage at least, if not the entire passage, should be gunmetal or bronze, as iron does not preserve a sufficiently good surface for high velocity conditions. Common practice is to provide only three sides of the guide passage in bronze, Fig. 13, but this can only be defended on grounds of cheaper first cost. For best results a bronze-plate should be provided to box-in the passage, the plate being attached to the guide-vane casting or dowelled to the casing. Guide-vanes are sometimes cast completely boxed in, and this method necessitates hand finishing of the passage by file and scraper; open vanes, however, lend themselves better to cleaning out and accurately finishing either by hand or by machining.



Figs. 14 and 15.—Impellers, unbalanced.

Unequal side area. One rubbing shoulder. — Equal side areas. Two rubbing shoulders.

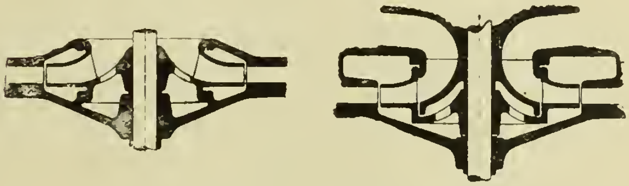
A good smooth surface is essential for the best results and will always justify the increased cost.

The method adopted of securing guide-vanes from rotation and vibration must be a thoroughly sound one or trouble will result.

II. Impellers.—Impellers are either:—

(1) Single entrant, or

(2) Double entrant.



Figs. 16 and 17.—Impellers, balanced.

The first is almost universally in use for multicellular pumps, and the second almost exclusively for single-chamber pumps; it is only proposed to deal with the single entrant form.

Multicellular pumps use the single-eye wheel in three forms:—

(*a*) Unbalanced, unequal side area, one rubbing shoulder, Fig. 14.

(*b*) Unbalanced, equal side areas, two rubbing shoulders, Fig. 15.*

(*c*) Balanced—on paper, Figs. 16 and 17.

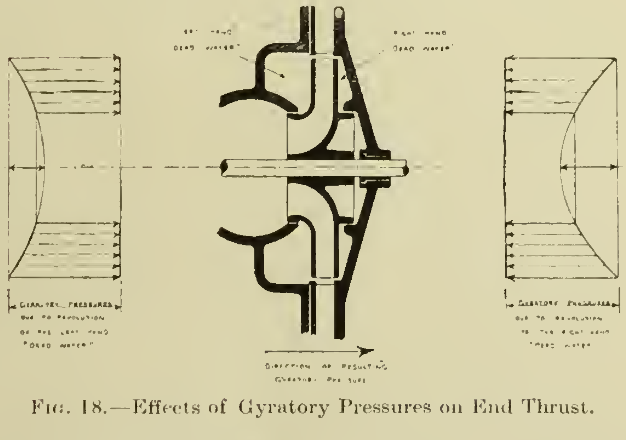


Fig. 18.—Effects of Gyratory Pressures on End Thrust.

There are other types, mixed flow, radial and axial, etc., but these are not used to a sufficient extent to be worth including in this paper.

* *See* also Hopkinson and Chorlton Patent, No. 8,855—1904.

Type (*a*) may be said to be the one now generally used, that is, the preferable design.

Type (*b*) has certain advantages for machining, etc., but probably requires a stiffer shaft. Also, having no central supports, it tends to rotate the suction water of the next impeller and may be attended by greater stage leakage due to the increased annular running clearance.

Type (*c*) has the *paper* advantage of being in balance; actually it is a poor approximation to a balance. Disturbing factors are set up by: differences in side pressure on the impeller due to differences in volume and surface-form of the water contained on the two sides of the impeller, Fig. 18; differences of quantitative leakage through the two shoulders; and high-pressure leakage *into* one side of the impeller from the stage above, and leakage *from* the other side of the impeller to next low-pressure stage below. Therefore, in practice, it is necessary to provide an additional end balancing device of the hydraulic type, or a mechanically positioning fitting such as a thrust-collar or ball-bearing; a method, specially for mine usage, not to be recommended.

The internal design of all impellers is governed by the same controlling features:—

(1) The entrance or inlet angle of vane.
(2) The delivery or exit angle of vane.

The entire design must, while based on these considerations, consult the convenience of the workshop to the utmost degree possible without departing from required dimensional accuracy. The standing difficulty with turbine-pumps, from the manufacturing point of view, is their constant variation to meet the infinite number of conditions of varying head, speed, and quantity encountered in practice. Whatever efforts are made, it seems impossible to keep to a small number of standard impellers if the highest efficiency is to be reasonably well reached each time. Efficiency, it should be noted, is really the prime factor in design and not apparent first cost, for the pump is very often driven by an electric motor of greater value. If, therefore, by the use of a pump of higher efficiency, a reduction is effected in the necessary power and size of motor, the combination will generally come out cheaper.

The maker who elects to change his impellers and diffusers to suit the demands of the inquiries as they come in, will obtain a higher percentage of orders than one who has standardised his, even though the latter may have reduced costs by making in large quantity. In considering if in any way it is possible to meet the designer's requirements without losing all the advantages of repetition manufacture, we may first take the inlet angle. This depends on the resultant of the (supposed) radial flow of the entering water and the peripheral speed of the inlet tip itself, and it usually varies between 15 deg. and 30 deg. If we select to use always 15 deg. we might suffer in some cases to the extent of 3 per cent or 4 per cent. If we take two sizes, 15 deg. and 25 deg., and make a liberal provision of inlet width, or, as some designers phrase it, make an adequate allowance for "weir coefficient" at entrance, we shall only drop perhaps 1 per cent in exceptional cases; so it seems possible to do something in the way of standardising the inlet angle.

One might refer, in passing, to some of the current ideas concerning the inlet angle and the condition of the water at entry to the impeller. Some designers have maintained that very great accuracy of the inlet angle is vital to high efficiency, in spite of the fact that in the ordinary unobstructed eye it is impossible to say what the absolute velocity and direction of the incoming water is, and, therefore, to estimate precisely what the correct inlet angle should be is impossible. Further, the behaviour of the incoming water varies with every rate of flow, and the only way to foretell its condition would be to insert inlet guide-vanes; this, however, in such experiments as the Author is aware of, has proved an objectionable practice and only introduces further losses in the pump. Another school holds that it is an advantage purposely to introduce a forward whirl in the water at the eye with the object of helping the water into the impeller. If such an initial whirl is used, the work necessary to create it is necessarily done by the pump itself, and it is, therefore, questionable if this does not entirely overweigh any possible gain.

The discharge angle depends on the resultant of the peripheral speed of the wheel and the radial outflow, the variation of which is so great it seems impossible to devise any standardisation. To meet quantity variation two widths of impeller may be used, and to meet required speeds of revolution it is usual to allow a small percentage variation in the impeller diameter to suit special demands; this latter, however, is conveniently done without pattern or casting alterations.

The foregoing considerations lead to the conclusion that nothing less than a special core-box will be required for each case, and it is quite usual to meet the difficulty in this way. Evidently, however, a most valuable appliance would be a special form of core-box, which in itself was more of a standard and could be adopted for manufacture in quantity; this result might be effected by fitting in vanes of a flexible nature, so that the necessary alteration and adjustment would not be great, and the whole outfit would come out cheaper than if a pattern-maker had to build a fresh box and fittings for each new demand. As the accuracy and smoothness of the impeller is of great importance, the author has always looked to machine moulding, and to a special machine like a wheel-moulding machine, for the purpose; he has not, however, as yet, arrived at the final design for such.

The surfaces of the impeller, both inside and out, play an important part in the efficiency of a turbine-pump. The smoother the outside surface the less the power lost in disc friction, and the less the power wasted in revolving idle "dead-water."* An interesting point to note is that the greater the speed of revolution of the "dead-water" (that is, the greater the power absorbed in this way), the less the leakage from the periphery of the impeller; but a little consideration will show that greater overall

* *See* Professor Gibson's Disc Friction Experiments, already referred to.

economy is gained by reducing the wasted power in idle revolution to a minimum. As regards the internal smoothness of the passages of the impeller, it is usual practice to clean up the surfaces as well as possible with file and scraper. Impellers have been built up with one loose side so as to permit of machining or more effectively cleaning the interior; and it is evident that with individual impellers producing high heads the results would well repay the extra cost. Objections to this practice are the difficulty of making attachment of the two parts and the extra weight necessary to provide attachments.

(*To be continued.*)

## VALVE TROUBLES AND SOME CURES.

By C. H. W.

There probably is not a steam power plant engineer in existence that has not been confronted with the frozen valve stem trouble. We have all had more than one or two of these disagreeable out-of-the-way valves that were opened and shut only once in a while, and finally, just when they were needed to cut a section of the line, or to by-pass something, they would not budge, even with a good-sized monkey-wrench used as a leverage on the hand-wheel. This generally twisted the stem off or twisted it so badly that a new one had to be made in the shop.

My plan when I find a valve with the stem frozen in the yoke, or one that works so stiff that the use of a wrench to move it is required, is to take a gasoline torch, heat the yoke around the stem, tap good blows with a suitable hand hammer, and keep persuading the stem to move back and forth, using fine strips of emery cloth to clean the threads close to the yoke, blowing the dirt away before entering the cleaning part into the yoke. Patience is required for this work, especially if the valve is located in an uncomfortable place.

When the stem fails to move after trying the heating as above mentioned, there is but one other method that I know of to try. This is to take the valve bonnet off and to remove the disc; then tap the ends of the valve stem in addition to the yoke. Secure the bonnet in a vice, or, if the valve is too large, clamp it to some angle-plate. A pipe wrench can be used on the part of the stem next to where the disc was secured, and the hand-wheel and another wrench can be used on that part of the stem above the yoke. This method gives the power to move, yet divides the twisting strain between both ends of the stem. This, of course, can only be done if you are able to take the valve apart, having no pressure to deal with.

After getting the troublesome stem out and cleaning the threads of the stem and yoke, if you cut a slot similar to a keyway down through the threads on one side of the stem, this will always clean the threads out each time the valve is used, and it does not weaken the stem enough to do any harm. I have tried this on more than twenty different size valves, and it works splendidly.

Many times a steam valve is closed so tightly that it seems like the stem is frozen, when really all that is wrong is that the valve has been jammed shut and the line temperature changed so that it has contracted the parts of the valve, and thus set the valve disc tighter on the seat. When a valve is found in this condition, the yoke through which the stem works can be slacked away enough to ease the strain, and then the stem can be moved.

When the valve is one in which the yoke cannot be slacked away from the bonnet or bonnet studs on account of its design, the best thing to do is to slack the bonnet away at the flange. Of course, this means that the pressure on the valve must be taken off first.

These methods will save considerable damage to the valves if one has a little patience.—*International Marine Engineering.*

## PRODUCER GAS AND ITS INDUSTRIAL USES.*

By F. W. Steere.

One of the greatest problems now confronting industry is, undoubtedly, the fuel problem. It is the same old story of prodigal waste until we suddenly find ourselves face to face with a real shortage. The subject of this discussion is to consider the possibilities of one of the methods of utilising soft coal—that is, by converting it into producer gas. This gas is by no means the panacea for all our ills, but it has its place, and our duty now is to determine to what extent its use can be applied in conserving our natural fuel supplies.

For many years producer gas has been successfully used in metallurgical work for heating large furnaces, for melting glass, etc. These operations are carried on with hot producer gas—that is, the gas from the producer off-take, which is usually at a temperature of from 1,200 deg. to 1,400 deg. Fah., is led directly to the furnaces through brick-lined flues. Producer gas made from soft coal carries large quantities of tar, soot, and dust in suspension. It is impossible to keep a large part of this solid matter from being deposited in the flues between the producer and the furnaces. This deposit must be periodically removed by "burning out."

The only practical means for utilising producer gas in the great variety of heating operations which are found, for instance, in the automobile industry, is to clean the gas completely of all suspended matter and cool it to normal room temperatures. It then can be distributed through any system of piping the same as ordinary city gas. The big problem has always been to make a gas free from both tar and soot. This difficulty of getting clean gas has, undoubtedly, had more to do with the slow development and adoption of producer gas than all other things combined.

Two general types, or classes, of producers have been developed, the distinguishing characterises of which are the methods of cleaning the gas: (1) Producers where it is attempted to convert all of the tar to a fixed gas before leaving the producer; (2) producers which make a tarry gas and rely on outside apparatus for cleaning it. Suction and pressure producers are found in both of these classes.

The producers of the first class are built on the theory that if the hydrocarbon vapours, tar oils, etc., which go to make up the very complicated combinations of material that are usually designed as "tar," are brought in intimate contact with highly-heated surfaces, these tar constituents will be cracked to fixed gases. The down-draught producers, double-zone producers, and under-feed producers illustrate this class. In these machines the gas is made to pass through the heated portions of the fuel bed, relying on the contact with the incandescent coke to bring about the cracking.

All of the simpler forms of producers, where the fuel is charged at the top and steam and air are blown in at the bottom, come under the second class. The tarry vapours

* Abstract of paper read before the Detroit local section of the American Chemical Society.

which are distilled from the top of the producers, obviously, pass out with the gas and must be cleaned by some external means. This problem of removing tar from gas made in producers of the second class has been attacked from almost every conceivable angle, such as washing, scrubbing, complicated spray systems, deflectors, centrifugal and whirling machines of almost infinite variety, filtering, pressure and sudden expansion, and precipitation by high-tension electrical discharges.

The high-tension electrical process for detarring gas was invented by the author in 1911. The following extract from a paper entitled "An Electrical Process for Detarring Gas," which was read before the American Gas Institute in 1914, describes what takes place in the "Ioniser" where the gas is passed through the high-tension electrical discharges:—

"An opportunity was provided at the Detroit plant of the Semet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory, although far from complete, has proved sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

"In attempting to briefly outline the electrical action, we must keep in mind first that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra-violet light, etc. This process of separating neutral gas molecules into electrically-charged parts or ions is celled 'ionisation.' It is outside the scope of the paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist—that is, recombine to form neutral molecules, almost the instant they are outside the ionising influence. A very few molecules are continually splitting up, presumably because of the trace of radio-active substances found in most gases as well as in the atmosphere.

"Prof. Millaken, of the University of Chicago, has studied the movement of a small drop of oil between two oppositely-charged condenser plates when attacked by atmospheric ions. The drop receives a charge when atomised, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

"Let us recall that there are about 27 billion molecules in 1 sub. cm. of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible 54 billions ions per cubic centimetre attaches itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionised.

"This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionising field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm centre of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief, and it might naturally be supposed, as it heretofore has been, that an aimless to and fro movement of them would be the result of applied energy. It would, however, be hard to conceive of a condition more favourable to impact between tar particles, and experience shows that either because of this impact or for some reason as yet unknown, agglomeration results, and the dense tar mist is almost entirely dissipated, leaving a relatively few large tar drops in its place. This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on the whole field can be seen to clarify. The commercial importance of this becomes more apparent when we realise that this action can be brought about at almost any desired temperature.

"No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionising field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor, where a complete removal is effected with very little power loss.

"The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in removing relatively large drops, and the electrical treatment simply converts the fine mist into the large drops."

Enormous sums of money have been expended in attempting to perfect a commercial process—that is, a process which would deliver clean gas of uniform calorific power continuously. The great difficulty which has always been met lies in the fact that the success of any gas-making process depends almost entirely on the skill with which it is operated. Machines and processes may give perfect results in the hands of the inventors, or skilled operators, but when they are sold promiscuously and are handled by unskilled, or different, operators the result is failure. This has been the history of the gas-producer development for years past, with the result that all clean gas-producer development work is looked upon with a great deal of suspicion.

*(To be continued.)*

## INDUSTRIAL PROTECTION.

By A. L. Haas.

Owing to past political battles on the question of tariffs, Free Trade and Protection, an unprejudiced consideration of the measures necessary to foster incipient industry is well nigh impossible.

The major plea for high protective duties was that they would stimulate infant industry; the removal of competition at home allowed growth and expansion, gave stability so that financial encouragement would be forthcoming. Opinion in Great Britain became sharply divided on the question and the advocates of the policy indicated failed to carry their point and effect a change.

Now, there is nothing supernatural about manufacture; what can be done in one country can be repeated elsewhere under similar conditions. Even where raw material is at the back door, it does not signify that the locality of production is by this alone enabled to take front rank as a maker of finished goods. The case of cotton and Lancashire is an outstanding and palpable argument to the contrary, owing nothing to Governmental interest on its behalf.

Successful manufacture at a distance from the source of raw material is dependent upon the relation between cost

of finished product and the initial basis from which it is made. Where considerable disproportion exists, the value of the finished goods being many times the cost of the raw material, it seems to matter little whether the factory is adjacent to supply or half a world away.

In very many industries, cheap power, a trained and skilled labour area served to establish better competitive conditions for relatively expensive goods, than the cheapness of transit due to locality.

War re-values, sifts and alters established and customary usages, it lops withered branches from the industrial tree, in the case of trade, commerce and manufacture it tends to establish new centres of gravity. In face of threatened extinction, industry revises its accepted beliefs, improves organisation, system, and process, and for these reasons may in the end be more thriving and prosperous than before.

Two main arguments have been used in political propaganda, the assumption being that they were directly opposed. These are, a belief that cheap labour is essential to export trade, the other that progressive manufacture and modern plant can compete successfully despite high wages. The two sides to the impasse are not diametrically opposed; it is efficiency which is sought, and it is certain that success is a question of capital expenditure on plant, coupled with organising brains and labour co-operation. High wages are economically sound where the proportionate return is adequate; in themselves they present no barrier. Without enterprise, cheap labour is an alternative solution, but not the only solution to success in industry. It is imperfectly realised that the present abrogation of international trade, due to the war, has an equivalent effect to that sought by the advocates of Protection.

Present high prices, the dire shortage of commodities hitherto imported, high freight rates and limitation of tonnage, the abrogation of patent protection to enemy subjects, the national need and stimulation of effort under emergency, are all playing a part in the inception of new, as well as the stimulation of existing, industries.

The results may prove a welcome surprise to ourselves, and one of another order to some others when normal conditions are restored. Nearly every manufacturer is planning the exploitation of trade hitherto in enemy hands; nothing much transpires as yet because of shortage of labour and other easily-realised factors of the present situation. Without noise or fuss, as opportunity offers, drawings are being made, experiments conducted, samples made up, and plans laid for quantity production on the largest scale in so many quarters that it would be invidious to specify any. It took two years to reveal our true strength as a combatant, and from an industrial, as well as a military point of view, the renaissance of England proceeds apace. It is the biggest awakening the country has ever known, the specialised munition production and the experience gained thereby in many unaccustomed quarters will leave a legacy from the war of intensified production and possibilities hitherto undreamt of, and although this land has never lost her industrial pre-eminence, after the war her expansion industrially will inevitably be enormous.

To take advantage of the flood-tide which leads to national fortune, will need all the financial and labour resources of the Empire; the reconcilement of the two seemingly opposed interests is the function of a future Government; the foundations must, however, be prepared now. Could some of the enthusiasm for national production for war emergency be carried over, and the feeling of national interest in manufacture be more realised than in the past, there is little doubt that the industrial future of England is assured.

By the present national need, national capital invested abroad has been liquefied; it may prove that in the future the exploitation of the Empire covering a fourth of the world's surface will give better returns than the alienation of its power elsewhere. The restoration of damage, the clearing up of the wreck caused by the world catastrophe, must involve all available labour. In place of provision against unemployment it may be found that the shortage of labour will be almost as acute as now.

To some, the future, after the restoration of peace, casts many black shadows before the event. There seems little need for such pessimism; morale is an essential to the soldier, and its corresponding industrial quality—belief in the future—is going a considerable distance to industrial victory.

The proven secret of national success in war is the realisation of identity of interest common to every individual, the same realisation of national identity in time of peace is going to yield equal results if its spirit can be engendered. The danger in both instances is individual exploitation, and restraint of this is one of the functions of Government, and if successfully accomplished it should prove possible that the present war will be ultimately a blessing rather than a curse.

Military victory means national prestige equivalent, in one sense, to commercial reputation. Starting, therefore, with national prestige, a trade reputation for sterling worth second to none, assuming that the lesson of national dependence upon each other has been learned, with the other lessons of industrial output necessitated by national emergency: there is little to fear, and all to hope from the future.

Indeed, to most acute thinkers, who look beyond the immediate present—the dark hour before the dawn—the prospects never seemed brighter. Although there are problems to face, the sun of England, far from declining, is in the ascendant, and its waning has been indefinitely delayed.

## REFRACTORY MATERIALS.*

The committee are glad to report that during the past year the provision of the necessary apparatus at the County Pottery Laboratory, Stoke-on-Trent, under Dr. Mellor, has made considerable progress, in spite of difficulties in obtaining delivery of apparatus. The necessary plant for the investigation of the question of refractoriness of material under load, and of the differences in size of bricks when cold and when at high temperature, has been completed for some time, and research in these respects commenced. The apparatus for investigating the influence of fine flue dust carried into the setting on the refractoriness and life of the materials employed is now also practically complete.

In previous years the work done has been chiefly carried out on manufactured materials obtained from different makers or on material taken from deliveries to different gasworks. As stated in last year's report, it had been found essential to employ in the work, in addition to such material, bricks which had been manufactured from known materials and under exactly defined conditions, and Dr. Mellor had been authorised to arrange for the manufacture of such bricks. A large quantity of clay, amounting to about 20 tons, has been obtained from six sources, repre-

* Report of the Refractory Materials Committee of the Institution of Gas Engineers, presented June 5th, 1917.

sentative of the different varieties of material found in the United Kingdom, and has nearly all been made into bricks for testing purposes. The method of manufacture has been varied for the different qualities of clay, both in respect to the quantity, fineness, and firing temperature of the grog, and in the firing temperature of the finished brick. The bricks, thus made in such a manner that their "life history" is known, will be employed by Dr. Mellor in the various researches now in progress.

Sets of 100 of different kinds of bricks are also being fired in industrial furnaces at about 1,300 deg. Cen., five of which are removed after each firing (extending over eight days). When the 20 firings are completed the bricks will all be examined to observe deterioration according to the length of time of firing.

The hot to cold measurements of the bricks collected as typical of those on the market are completed, and the results obtained are given in detail in the report of Dr. Mellor. The results obtained are such as to cast some doubt on previous measurements of the coefficient of thermal expansion of firebricks and related materials at high temperatures, as the true thermal expansion is obscured by effects due to the after-expansion or after-contraction of the firebrick which is taking place while the bricks are being measured. The work carried out by Dr. Mellor in this respect demonstrates the importance of taking into account the continued alteration in the character of bricks under prolonged or repeated heating.

A number of measurements of the after-contraction or expansion of firebricks have been made to test the conditions laid down in this respect in the standard specification, and the results obtained are given in Dr. Mellor's report. The general conclusion derived from this series of tests is that the tendency is for ordinary silica bricks to give a less expansion, and firebricks of fireclay to give a greater contraction in the reducing than in the oxidising atmosphere.

The tests on the refractoriness of whole bricks under load are not yet completed. Quite a number of unforeseen difficulties have arisen and been overcome. Dr. Mellor has had to investigate the difference in temperature between the interior of the brick and the outside when the softening temperature is actually determined, and in order to ensure that the interior and exterior shall be at one uniform temperature in a reasonable time—three to five hours—test pieces of about 3 in. by 3 in. appear to be most suitable. If the test pieces are 1 in. by 1 in. or less their preparation interferes with the structure, and fallacious results are obtained under load. Two large pieces of grog, for example, side by side would produce a weak spot which would break down far below that temperature which is a true characteristic of the brick. Unfortunately, difficulties increase as the size of the test piece increases. These tests are being continued with the bricks which have been specially manufactured under known conditions, as well as with standard bricks on the market.

Apparatus has also been ordered for the investigation of the effect of a reducing atmosphere on refractoriness, but this has not yet been delivered.

The question of modifications of the standard specification has been further considered, but it was felt that under existing conditions it would be inopportune to make any material changes in the tests specified; two alterations have, however, been made in the specification relating to retort material. The wording of the specification relating to the material to be employed in the manufacture of retorts might be taken to preclude the admixture of silica material with the fireclay used for retort manufacture. To prevent any misconception on this point words have been added permitting the use of silica material, and Clause 1 now reads as follows: The retorts or retort tiles shall be made of sufficiently seasoned raw clay compounded with clean burnt clay or grog; they may also be made from suitable silica material. No "grog" shall be used which will pass through a test sieve having 16 meshes to the lineal inch.

Further, although in the standard specification it is laid down that the porosity of the retort material should be 18 per cent as a minimum, no maximum porosity is specified, as at the time the specification was drawn up no sufficient data were available for fixing such a maximum. In view of the experience gained since then it has now been agreed that, in addition to a minimum porosity of 18 per cent, a maximum porosity of 30 per cent shall now be specified.

With respect to the expenditure of the committee, the cost of the apparatus ordered during 1916 would have exceeded the funds at their disposal but for the fact that, owing to late delivery of the apparatus, some of the accounts did not become due for payment until after the financial year had closed, and allowance has to be made for the payment of this surplus during the current year. For this year the Institution and the Society of British Gas Industries have each increased their grant for 1917 from £50 to £150. Application has also been made to the Advisory Committee of the Privy Council for Scientific and Industrial Research to increase their grant for 1917 from £130 to £300, and the Institution has now been officially informed that this application is granted. The increased sum thus available will enable the committee to expend a larger sum in the payment of qualified men to act as whole-time assistants under Dr. Mellor to carry on the necessarily lengthy and detailed tests. Last December, as soon as the necessary apparatus was sufficiently advanced to permit of further work, an assistant was appointed for this work, and additional assistance will be provided as the conditions enable this to be done with advantage, if suitable qualified men can be obtained, a matter not at all certain under present conditions.

During the last year a number of developments have taken place in connection with the subject of refractory materials, and the requirements of the whole of the industries of the United Kingdom in this respect. At the end of the year a "refractory materials section" of the Ceramic Society was instituted to form a technical society for dealing with matters relating to the manufacture and development of refractory goods. The membership of this section is open to users as well as manufacturers, and meetings of the section will be held twice a year at different centres.

A general discussion on the subject of refractory materials was organised in London last autumn by the Faraday Society, and following on that discussion, at the instance of the Iron and Steel Institute, a meeting was arranged of delegates of a large number of technical societies to consider what steps might be taken towards the co-ordination of research work on refractories and to endeavour, if it seemed desirable, to secure joint action in carrying further the work of standardisation. The Council of the Institution appointed the chairman and vice-chairman of the Refractory Materials Committee as delegates to this conference, which was held on March 22nd. After a general discussion of the subject a sub-committee was appointed of the following members: Mr. A. Cliff, Prof. J. W. Cobb, Dr. R. T. Glazebrook, F.R.S., Sir R. Hadfield, F.R.S., Mr. Cosmo Johns, Dr. J. W. Mellor, and Dr. A. Strahan, with Mr. F. S. Spiers as secretary.

# HANDLING COAL AND ASHES IN POWER PLANTS.

By Henry J. Edsall.*

A few years ago the part of the power plant which was receiving especial attention, and for which the equipment was being most carefully perfected, was the generator room. Now the boiler room is beginning to receive the attention which it deserves, and the possibilities of saving money by more efficient opertion, and by saving labour in the handling of coal and ashes, are rapidly being appreciated.

Since fuel is the largest single item of expense in the generation of power at a steam power plant, and the handling of it the principal labour expense, it is only natural that efficiency in the handling and firing should mean a great deal in dollars and cents. This is, of course, especially true at this present time when the cost of fuel and the cost of labour are both so high.

### Methods of Feeding Coal.

Boiler rooms of the present day may be divided into two general classes—hand fired and mechanically fired—the term firing being used principally to denote the method of feeding the coal to the furnaces, since a certain amount of human attendance and operation of the fires is required in either case. The number of hand-fired boiler rooms is gradually growing less, and as the mechanical stoker is improved and perfected its use increases so that even quite small boiler rooms are now equipped with them.

Since stokers are primarily automatic feeding devices, it is obviously illogical to shovel coal to them by hand. The whole operation of handling the coal should be made mechanical. This not only reduces the labour to a minimum, but, by taking out the most laborious part of the fireman's job, it makes it attractive to a higher class of man, and it also allows him to devote his time exclusively to the operation of the stokers, so that, as has been actually proved by experience, the efficiency is increased and the coal bill thereby reduced. In cases the fuel saving by the more efficient operation which the mechanical handling of the coal makes possible amounts to 15 per cent or more.

The usual method of feeding the coal to the stoker magazine is to first put it in an overhead bin, by means of conveyors, and then feed it by gravity through spouts direct to the stoker magazines. With such an arrangement the overhead bin must be directly over the space in front of the boilers, or near enough to allow for the proper slope of the stoker spouts.

Another method of delivering the coal to the stoker magazines is to draw it from the bin into a travelling lorry or weighing hopper, which can be moved along in front of the stokers and the coal delivered to the magazines. In this case the bin can be located wherever convenient, and the spouts placed close together so as to drain the coal out effectively. On the other hand, the operation of the weighing hopper requires the services of a man for part, or in some cases, all of the time. In hand fired boiler rooms, since in any cases the coal has to be shovelled into the furnaces, the overhead storage bin does not show such a labour-saving advantage, though they are sometimes installed in such boiler rooms because of a certain amount of labour saving, by eliminating the necessity of the firemen or coal passers wheeling more or less of the coal. They also made a neater and more ship-shape boiler room possible, and avoid the confusion accompanying the handling of coal to the furnaces by wheelbarrows or other hand-methods. In congested districts in cities the overhead bin is frequently the only logical method of storing the coal, since additional ground space is too valuable to be spared for ground storage.

The problem of unloading coal which is received by rail, or by automobile trucks or wagons, is quite different from the problem of unloading from boats. In the former case the coal is usually dumped into a hopper or pit below the track or ground level, and the hopper is designed so that the coal will feed to a conveyor system. In unloading boats the coal must be picked up out of the boat and then taken away by a conveyor system or otherwise.

### Points to be Considered.

The type of equipment required for handling coal which is received by rail, or by wagons or trucks, depends on the kind of coal handled, the number and location of the discharge points, whether ashes are to be handled by the same machine and various local conditions. Where free flowing, sized anthracite coal is to be handled, it is easy to feed to conveyors, and the absence of large lumps makes it unnecessary to provide conveyors with large carrying parts, except for large capacity. Where very fine anthracite or bituminous coal is handled, it tends to choke at openings and sticks on hoppers and chutes, and considerable care has to be exercised to avoid trouble.

Sized bituminous coal is also obtainable and is used to a considerable extent, but by far the larger quantity of coal used for steam-making purposes is run-of-mine bituminous coal containing more or less large lumps.

Where the firing is done by hand these lumps do not have to be broken up very carefully, but where mechanical stokers are used it is important to reduce the lumps to a uniform size, usually of two or three inches and under. For this purpose a standard two-roll coal crusher is ordinarily used, and it is placed, as a rule, underneath the unloading hopper, but to avoid choking the crusher and also to reduce the power required, an automatic feeder is provided to feed the coal regularly to the crusher. The feeders most used are the apron feeder and the reciprocating feeder. The former is a steel apron made up of overlapping steel slats attached to two roller chains which operate over sprocket wheels at each end and travel on rails or angle iron tracks in between. This apron forms the bottom of the unloading hopper, so that the coal in the hopper rests on it, and, as the apron moves slowly forward, the coal is bound to move with it. The speed of travel of the apron regulates the rate of feeding.

With the reciprocating feeder the moving apron is replaced by a steel plate resting on rollers and to which a reciprocating, or forward and back, movement is given by means of an eccentric or crank. As the plate moves forward the coal resting on it also moves forward, and some of the other coal in

* Engineer with Link-Belt Co.

the hopper slides down at the back. As the plate moves back the coal at the forward end falls off into the crusher. The rate of feeding depends on the length of the stroke and the number of strokes in a given time.

**One Machine for Coal and Ashes.**

For elevating the coal and distributing it in the bin, there are various types of conveyors, some of which are suitable only for elevating, others for distributing, and still others that are so designed that both these objects can be accomplished with one machine. Another object to be accomplished is the handling and disposal of ashes, usually by taking them up to an overhead bin from which they can be delivered by gravity to wagons, cars, or possibly to boats.

While coal is comparatively easy to handle and causes very little wear of the machinery, the handling of ashes is not quite so simple. They are gritty, do not flow freely, and when they are quenched with water they become more or less acid, so that they tend to corrode some of the metals quite rapidly, especially steel.

It will be readily appreciated that simplicity of equipment in solving a conveying problem is a decided virtue. The fewer the number of machines used and the less driving machinery and other parts, the fewer the possibilities of trouble and the fewer parts to maintain and renew. If, therefore, several lighter and cheaper machines, with their multiplication of driving parts, can be replaced with a single rugged and carefully-constructed machine, the saving in trouble, worry, and maintenance cost will justify the installation, even if the first cost is somewhat greater. It has, therefore, been the aim of the conveying machinery engineer to build a machine which would satisfactorily elevate and distribute the coal in the overhead bin and also receive the ashes, at convenient points at each boiler, and take them up and deliver them to an ashes bin for disposal in the most convenient manner.

As is the case in most new developments, certain difficulties and requirements were not at first properly appreciated, and faults in design and construction of some of the machines made them an expensive proposition to maintain and a source of worry and annoyance. This naturally instilled prejudices in the minds of many people against this kind of system, and these prejudices still exist in some cases. As a matter of fact, some of the machines of the present day are not what they should be, but the value of the system has been amply demonstrated by its great and increasing success. It is now used in many of the best power houses in the country and the use is rapidly increasing.

**Pivoted Bucket Carrier.**

The type of machine used for this system is known as the pivoted bucket carrier. The buckets are attached to two strands of long pitch, usually 18 in. or 24 in., roller chain in such a manner that they keep their upright, or load-carrying position when travelling vertically or horizontally and at the desired point they can be tipped over by a discharger and the contents dumped out. When travelling horizontally or on a slight incline the buckets are continuous and the lips are made to overlap to avoid spilling material between them when loading. The large flanged rollers at each chain joint travel on T rail tracks, supported on cast-iron rail chairs, on horizontal or inclined runs, and when travelling vertically they are confined between double T rail guides, also attached to cast-iron rail chairs.

In the best machines the bearing surface in the chain joints is largely increased and the bearing pressure thereby reduced by using good sized bush-

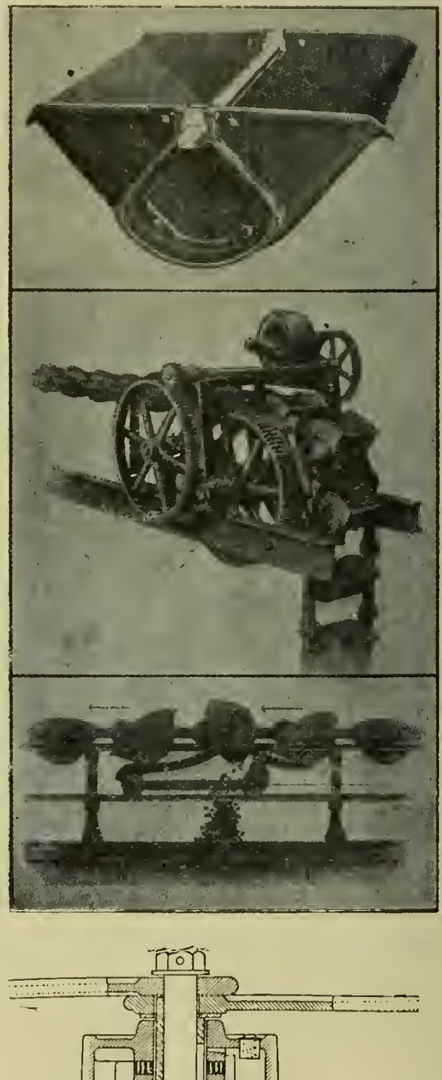


FIG. 1.—Details of Peck Pivoted Bucket Carrier.

ings of case-hardened steel and pins of generous size made of high carbon steel. These pins and bushings relieve the links of all wear and last for a very long time. When they finally do become worn they can be renewed at comparatively small expense. The rollers of the chain are provided with oil chambers which carry a supply of oil sufficient for several weeks of ordinary operation and this oil

filters slowly through felt washers to the bushings and on through slots in the bushings to the pins, thereby insuring a perfectly oiled joint.

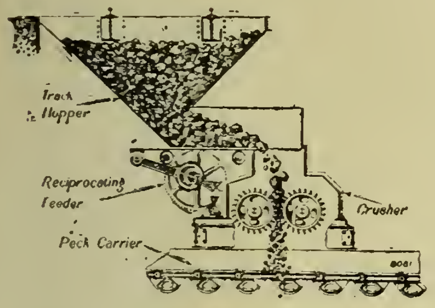



Fig. 3.—Track Hopper, Apron Feeder and Crusher.

The buckets and links are made of malleable iron, which withstands corrosion to a remarkable degree and which also allows these parts to be built to the most suitable shape. Where the buckets are loaded, guard plates are provided which deflect the flow of material to the centre of the buckets and also protect the chains from the material. The speed of travel is quite slow, usually 40 or 50 ft. per minute, and this feature, together with the well-oiled rollers of generous size and the fact that the up-and-down runs balance each other, except for the weight of material on the ascending side, keep the power required for operating these machines down to a very low point.

The sizes and capacities of standard machines are given in the table below:—

| Bucket. | Pitch of Chain. | Carrying Capacity of Bucket in cub. ft. | Capacity of Coal-tons per hour. | Speed—Feet per minute. |
|---|---|---|---|---|
| 18″ × 15″ | 18″ | 0·68 | 15– 20 | 30–40 |
| 18″ × 21″ | 18″ | 0·94 | 20– 30 | 30–40 |
| 24″ × 18″ | 24″ | 1·68 | 40– 50 | 40–50 |
| 24″ × 24″ | 24″ | 2·24 | 55– 70 | 40–50 |
| 24″ × 30″ | 24″ | 2·80 | 75–100 | 40–50 |
| 24″ × 36″ | 24″ | 3·36 | 95–120 | 40–50 |
| 30″ × 24″ | 30″ | 3·50 | 95–120 | 45–60 |
| 30″ × 30″ | 30″ | 4·37 | 110–160 | 45–60 |
| 30″ × 36″ | 30″ | 5·25 | 140–190 | 45–60 |
| 36″ × 36″ | 36″ | 8·50 | 210–330 | 50–80 |

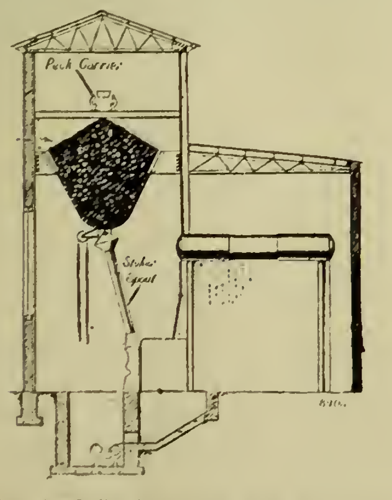



Fig. 4.—Boiler Room with High Roof over Bin and Low Roof at Rear.

**Details of Carrier.**

Some of the details of one of these carriers are shown in Fig. 1, at the top the bucket, next the

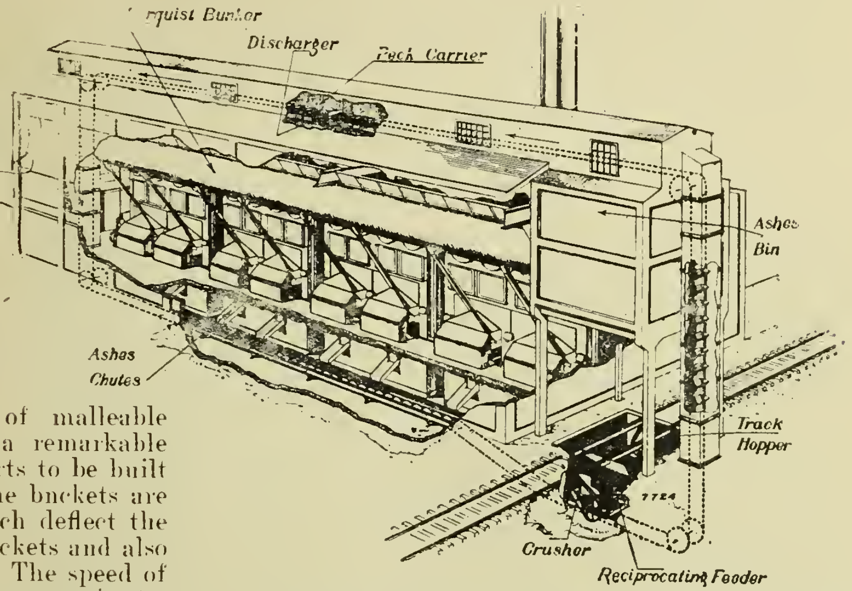



Fig. 2.—Typical Boiler House equipped with Overhead Coal and Ash Bins—Spouts to Stokers and Pivoted Bucket Carrier for handling both Coal and Ashes.

driving head, then the discharger in operation, and at the bottom a diagrammatic view of chain joint.

Fig. 2 shows a typical design of a boiler-house equipped with overhead bins for coal and ashes with spouts direct to the magazines of the mechanical stokers, and with a pivoted bucket carrier for handling both coal and ashes.

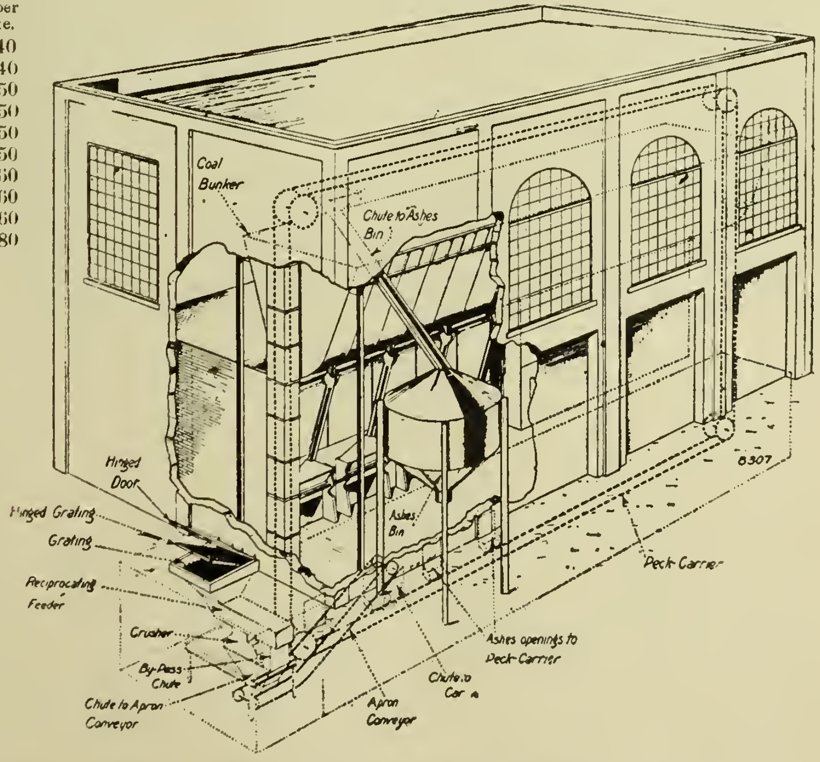
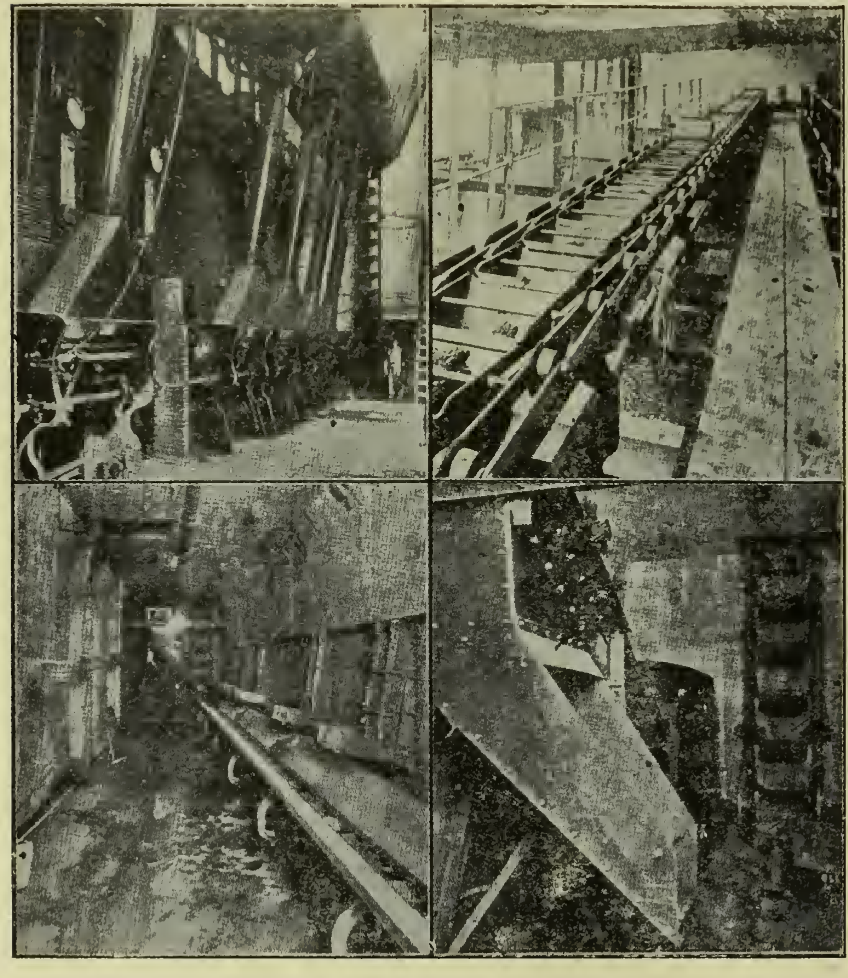



Fig. 5.—General Arrangement of Coal and Ashes Handling Equipment in new Boiler Room of Thos. Wolstenholme, Sons & Co., Inc., Philadelphia.

A larger detail of the track hopper, crusher, and feeder is shown in Fig. 3. The coal is unloaded through the bottom doors of the railroad cars into the track hopper, underneath the track, and a reciprocating feeder feeds it to the crusher.

After passing through the crusher the coal goes into the buckets of the carrier, which elevate it and distribute it in the overhead bin, from which it is spouted direct to the stoker magazines. The ashes drop into hoppers under the stokers and are, at proper intervals, fed to the lower run of the carrier in the basement and taken up to the overhead ashes bin for delivery to railroad cars. This makes a simple and reliable equipment which requires little attention and the handling of both coal and ashe is practically automatic.



Interior views, New Boiler Room, Wolstenholme Plant; top, left, Overhead Bin and Spouts to Stokers; top, right, Upper Run of Bucket Carrier over Bin; bottom, left, Lower Run of Bucket Carrier in Basement: bottom, right, Upper End of Apron Conveyor and Spout to Peck Carrier.

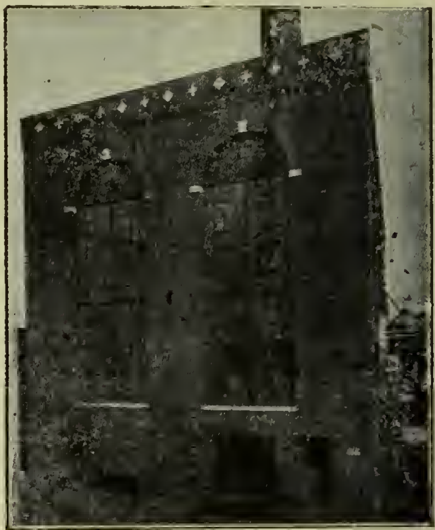
## Overhead Coal Bins.

The type of overhead coal bin that is most used and is most economical of steel is known as the suspension bunker. The weight is carried on plate girders which form the upper part of each side of the bin; the lower part of the bin is formed by plates suspended from the girders and bent to take the shape that they naturally tend to assume when the bin is full of coal.

The plate girders are supported directly on columns or on cross girders, which in turn are supported on columns, the front columns usually being set in the building wall, or close to it, and the rear ones placed close to the boiler fronts between the boilers, or in some cases the boiler columns are made heavier and used to support the bin also. The ends of the bin girders are sometimes supported on the end walls of the boiler room.

Bins of the suspension type are also built of reinforced concrete; the Brown hoist patent bin using ferro-inclave reinforcing plates with the addition of steel plate saddles or hangers at intervals being an example. The steel plate bins are also lined with concrete at times, though it would seem more logical to spend the money for heavier steel plates and give them a coat of good paint at stated intervals.

An economical design of a boiler room using a suspension bin supported on cross girders and with the columns set in the walls and close to the boiler fronts is shown in Fig. 4. This design gives a clear space on the operating floor in front of the boilers, makes the building high in front, where height is needed for the bin, and low at the back, and it breaks the roof trusses up into two spans of lighter construction and supported partly on the bin and partly at the rear building wall, either on columns or on the wall itself.



Outside view of New Boiler Room, Wolstenholme Plant.

## Measuring Coal Delivered.

When it is desired to weigh the coal before it is delivered to the stokers it is usually done either with a travelling weighing hopper or by equipping each spout, or a group of spouts, with an automatic self-recording scale which has a hopper that weighs out stated charges, say 100 lbs. at a time, and delivers

them to the stoker spout, each charge being recorded by a counter. If there is not room in the spout for the charge, the bottom gate of the weighing hopper does not close and the upper gate does not open to feed more coal into the hopper until the coal gets away from the lower gate and allows it to close.

The travelling hopper is more flexible, since it can be moved to chutes in any desired location, but it requires the services of an operator when in use and, as ordinarily used, is given only a record of the total amount of coal delivered to all the stokers. In addition to this, the record of weights is dependent on the operator, and therefore brings in the element of uncertainty due to human supervision. With the chute, or group of chutes to each unit, equipped with a self-recording scale, the record is entirely automatic; no operator's services are required for the weighing and the record shows the coal consumption of each separate unit.

Two other methods for measuring the amount of coal delivered to stokers are the Havard coal meter, which is designed to measure the amount of coal passing down through a spout, and the scheme of using a tachometer or counter to count the number of strokes of the pushers when using the type of stoker which employs pushers or plungers to push the coal into the furnaces.

**New Wolstenholme Boiler Room.**

A good example of a pivoted bucket carrier system for handling both coal and ashes in the power plant of a textile mill is shown at Fig. 5. This is the new power plant of the Thomas Wolstenholme, Sons and Co., Inc., Philadelphia, designed by W. E. S. Dyer, engineer. The boiler room is 76 ft. long by 38 ft 9 in. wide, and it is designed for four 600-H.P. Edgemoor boilers, set in two batteries of two each and equipped with Wetzel stokers. The distance from the boiler fronts to the wall in front of the boilers is 12 ft., and above this space there is a steel suspension bunker of 250 tons capacity, with the girders framed into cross girders, which are supported on three pairs of Bethlehem H-columns, the front ones being set in the wall and the rear ones placed just back of the boiler fronts. The walls of the biulding are of brick, with large double windows in front of each battery, and the roof is covered with slag roofing and supported on wooden purlins resting on beams supported on the bin columns and on the walls. From the operating floor to the top of the cross-girders it is 32 ft., then 4 ft. more to the top of the cross-beams which support the conveyor stringers, and a clearance of 7 ft. from the top of the cross-beams, to the underside of the roof beams over the bin, on which the purlins rest.

There is no railroad siding at the plant, so the coal has to be carted in wagons or automobile trucks. The receiving hopper is built of ¼-in. steel plates and is about 5 ft. square at the top. It is located in a pit at one end of the building, this pit being 19 ft. 9 in. long, parallel to the end wall, by 8 ft. 2 in. wide, by about 12 ft. deep. The hopper is covered by two gratings and a steel door that can be thrown back against the wall. The upper grating has 4-in. openings so that the coal can be passed through these openings in case the crusher is out of service, or if it is desired to handle small coal which does not need to go through the crusher. When run-of-mine coal is to be passed through the crusher, the upper grating is thrown back and the coal is passed through the 8-in. openings of the lower grating.

At the bottom of the receiving hopper is a reciprocating feeder with the plate made of ¼-in. steel, 2 ft. 6 in. wide by about 8 ft. 6 in. long, with angle stiffeners and with a sliding door, 1 ft. 2 in. wide, where the coal goes through to the crusher. When the crusher is not being used the coal goes over the end of the plate and down into a hopper which feeds to a steel apron conveyor.

The crusher is of the standard two-roll type, with rolls 20 in. diameter by 24 in. long. The bearings of the roll shafts are carried by a cast-iron frame and the bearings of one roll shaft are backed up by relief springs, which allow this roll to move out in case a hard foreign substance gets between the rolls. The crusher is supported on steel framework resting on the concrete foundations. The coal which goes through the crusher goes into the hopper which feeds the apron conveyor, this hopper being constructed of ¼-in. steel plates.

The apron conveyor is 18 in. wide and constructed of No. 10 corrugated, overlapping steel slats attached to two 9-in. pitch steel roller chains with bushed joints. The rollers of the chains travel on steel angle tracks on both the carrying and return runs. The apron conveyor is about 21 ft. centres and extends through the end wall of the building, the part inside the building being inclined at an angle of about 26 degrees so as to take the coal up and deliver it to a $^{3}/_{16}$ in. steel chute leading to the buckets of the Peck pivoted bucket carrier.

**Handle 20 Tons Per Hour.**

The carrier follows a rectangular path about 70 ft. horizontal centres by 45 ft. 10 in. vertical centres with the upper run over the coal bin, the lower run in a tunnel or basement in front of the boilers, and the vertical runs close to the end walls of the building. The chains are 18 in. pitch malleable iron chains and the buckets are 18 in. long by 15 in. wide. They travel at a speed of 45 ft. per minute and handle coal at the rate of 20 tons per hour, or an equivalent amount of ashes.

The buckets take the coal up and out along the bin and it is discharged, at any point, by means of a movable discharger which has rollers that travel on T rails and which can be moved in one direction by the movement of the carrier and pulled back in the other direction by a wire cable which is wound up by hand on a small drum. The T rails for the carrier rollers to travel on are supported on cast-iron rail chairs, resting on the concrete floor of the pit on the lower run and on cross channels resting on I-beam stringers on the upper run. The upper rail chairs also support rails for the discharge rollers to travel on. There is a foot walk with a hand rail along the upper run.

The ashes fall into hoppers under the stokers, and, at certain intervals, are fed through gates to the lower run of the buckets, which have steel plate guards all along this run. The carrier buckets take the ashes up and deliver them to a spout leading to an outside overhead ashes bin, from which they are loaded to wagons.

**Power Required for Installation.**

The shafts of the lower corner wheels of the carrier are carried in stands resting on the concrete floor

of the pit and the bearings of the upper corner shafts rest on steel framework supported by the bin and the end walls of the building.

The motors for operating the machinery are wound for 220-volt, 3-phase, 60-cycle alternating current and the sizes are as follows:—

For the reciprocating feeder and apron conveyor, one 5-H.P. motor running at 1,140 revolutions per minute.

For the crusher, one 10-H.P. motor running at 1,140 revolutions per minute.

For the Peck carrier, one 5-H.P. motor running at 1,140 revolutions per minute.

The carrier motor is geared to the driving shaft with spur gears through an intermediate countershaft. The gears next to the motor have cut teeth, and the gears that connect the counter-shaft and the driving shaft are of the equalising type to eliminate the irregular motion always accompanying long-pitch chains. The reciprocating feeder is connected to the motor by means of spur gears, through an intermediate countershaft, and the apron feeder is connected to the countershaft by bevel gear and a chain drive.

The crusher is driven by means of spur gears through a countershaft. All gears have steel gear housings.

The spouts for delivering the coal to the stokers are 12 in. in diameter and have spreader ends for spreading the coal over the stoker magazines. They are built of No. 10 steel plate. Some other examples of coal and ashes handling installations at textile plants, using different types of equipment, will be described in a later article.

## INDUSTRIAL FAIRS.

A very excellent move has been made in this country to promote and hold Industrial Fairs. The glories of the Leipzig Fair are not forgotten, and no doubt there is a very fervent wish amongst German manufacturers that subsequent to the present war Leipzig will come into its own again. This we doubt; and we certainly hope that it will never be the case. It has been proved that we can exist without such German manufactures—that we can produce, or our Allies can produce, articles of equal merit. Therefore, why should we go back to any domination—and there was domination in certain classes of goods—by a nation that has caused so much human suffering and industrial chaos? Let us, therefore, support the Industrial Fairs of this country wholeheartedly, warmly, and at once. *Don't put off.* This has been a failing of ours for years; let it be dropped for ever. Glasgow notifies us of a Fair for 1918. February-March is the period, and particulars can be obtained from Mr. James M. Freer, General Manager, 38, Bath Street, Glasgow, or the Board of Trade, 32, Cheapside, London, E.C. Already, we understand, a great number of last year's exhibitors have secured space. Textiles are largely to the fore, and all classes of fabrics are to be shown. Cardboard boxes will have a section devoted exclusively to them, and no doubt many new designs will be forthcoming. It is high time we did more in the way of specialised exhibiting. Therefore, to all those who have goods to sell we say, apply for particulars of exhibiting at this and other similar Fairs.

## THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.

### MANCHESTER BRANCH.

By J. E. Jolley, Hon. Sec., Manchester Branch.

The last year has seen a remarkable development in the growth of the Association of Engineering and Shipbuilding Draughtsmen, to which the majority of draughtsmen now belong. In the Manchester district there is now a total membership approaching 1,100 men, representing over 70 of the more important firms in the area which is worked under the name of the Manchester branch. The area covered by this branch is a somewhat extensive one, viz., North to South, Preston to Crewe, and East to West, Warrington to the Yorkshire Border. At present this area is divided into 12 districts, viz., Ashton-under-Lyne, Altrincham, Bolton, Eccles, Oldham, Preston, Rochdale, Salford, Stockport, Stretford, South Manchester, and Central Manchester. In all these districts branch sub-committees are busily engaged in extending the utility of the Association.

The Association is no new growth, as so many who have noted its phenomenal progress imagine, but is the logical evolutionary extension of an already established organisation, an extension due largely to the pressing necessity arising from the national crisis, for an institution to voice the needs, the demands, and the advice of a body of men who, beyond all others, are responsible for the materialisation of the continuous progressive lines of modern engineering.

In face of the terrible demands upon the capacity of the engineering branch of the National Service, the time for narrow distinctions between the various grades of workers in the industry has passed, and the draughtsmen, recognising this, have abandoned the foolish policy of individual isolation, and have taken the sane and deliberate attitude of co-operation.

The parent branch of the Association was inaugurated some five years ago, at Glasgow, and, rapidly justifying its existence, gradually extended its influence throughout the country, individual members from all districts joining, with the result that on the realisation by the body of draughtsmen of the effects—both immediate, and to be expected in the future—of the war, various committees sprang up into being in the large engineering centres, and in the course of 12 months, working committees have been established in all the important districts.

There is a recognised Executive, and a general secretary, whose duties are to focus the activities of all on to the most urgent exigencies, in order to safeguard the rights and guard the interests of the members individually and as a whole.

The Association has not registered as a trade union, as naturally a body of men of such innumerably varying degrees of effectiveness wished to respect the business aspirations of the members, and rather to increase the efficiency of all, by the interchange of information through the medium of lectures, discussions, and instruction in technical matters, than to fix the scale of remuneration irrespective of ability or of technical accomplishments.

This attitude, however, does not debar the Association from seeking to obtain more equitable conditions for its members by every established lawful means, where it is evident that the past neglect of co-operation has resulted in the belittling of the importance of the draughtsmen's work and a corresponding attitude on the part of the employers to pay a wage, which, in pre-war times, was disproportionately low, and which under present conditions, without adjustment, has become unbearably small.

Unfortunately, there are cases even now where the managements have refused to make any concessions to the prevailing difficulties of living, and apparently seem to regard the depreciation of the draughtsmen's wage as a war-time sacrifice. This attitude is wrong, and it is my opinion that as the Association grows in strength, more of its attention will be devoted to the consideration of this essential point, affecting, as it does, the vital interests of its members. To be fair, I am glad to be able to state that a large number of firms have readily recognised the value of the work done in the drawing offices, and have made grants in the direction of paying a wage somewhat approaching the equivalent pre-war value. These firms are to be congratulated on their eminently sensible attitude, and will no doubt reap their harvest in the continued vigorous interest in production of the men concerned.

Above and beyond all the intimate interests of the members is the fact that such an organisation as we now possess will be a factor of great importance in the era of reconstruction which must follow the cessation of hostilities, and it is in such work that many of us will find the real purpose of life in the satisfying of a creative instinct, which is at the root of all social progress.

Acting under the advice and control of competent officials, there is no doubt that the Association will be able to exert a lasting and a beneficial effect on the future of the citizens of the world. A similar organisation is possessed by the draughtsmen of America, and also by various of the Continental nations, and intelligent reciprocal relationships with these is one of the aims for which the Association will be well advised to strive. Already we are in touch with our American cousins, and hope in the future to be of mutual assistance.

In the meantime representation should be sought on the various committees which, under the initiative of the Government, are being formed in the country—no reconstruction programme can be complete without the trained advice of the men represented by the Association of Engineering and Shipbuilding Draughtsmen. No educational syllabus should be compiled to forward the technical instruction of the younger workers without the help of our technical sections, which have already done excellent work in this direction. No work, constructive or destructive, education or utilitarian can be done without the combined efforts of the draughtsman and craftsman, and any policy which seeks merely the opinion of the latter and ignores the former, is deliberately stultifying its own activity. I would, therefore, in the interests of the members (and this is, reactively, the interests of the industry as a whole) point out that the Association stands apart as an organisation, wholly and solely representing the claims of draughtsmen to a fully recognised share in the nation's work, and demands in return a fair and equitable wage.

I feel sure that a realisation of the knowledge required by draughtsmen, a knowledge of all the various operations required to produce the finished article, an ability to make a theoretical design commercially possible, will result in an increased interest being taken in the profession, with the result that much initiative, previously restrained, will be more freely placed at the disposal of the community.

There is no need of rhetoric to enlarge on the benefits of organisation, as it is a truism to state that by co-operation the weak become strong, and the strong capable. As yet we are just passing the preliminaries of construction, our membership roll is filling rapidly, and shortly will contain a full 99 per cent of possibles. This preliminary work has been compared to the first turn of the tide: a few tired waves seem to be vainly breaking, gaining painfully inch by inch, with futile spray and foam, but the tide of the Association of Engineering and Shipbuilding Draughtsmen is coming to the flood, and will bear in the draughtsmen's bark from the silver waves to the golden strand.

A.E.S.D. (Manchester Branch), Rochdale District

GENERAL MEETING, RITZ CAFE (Yorkshire Street), 6 p.m. prompt, Saturday, September 29th, 1917. Speakers: J. E. Jolley, (Manchester Secretary); E. H. Broadbent (Manchester Technical Secretary).

Non-members welcome, if introduced by a Member.

P. W. GRIFFITHS, District Hon. Sec.

[A further notice *re* A.E.S.D. meeting appears on Page 480. —Editor, *I. E.*]

## TEMPERATURE MEASURING DEVICES.

In a paper, "Pyrometers: Past, Present, and Future," read before the Steel Treating Research Club, of Detroit, Mich., Richard P. Brown outlined the developments of the pyrometer.

### The Thermo-Electric Method.

After describing various other devices that had been developed and used with certain degrees of success for the measurement of temperatures, Mr. Brown added that for measuring temperatures above 1,000 deg. Fah. the thermo-electric method has come to be by far the most largely used. A thermo-electric pyrometer consists of a thermocouple, a measuring device, and the wires connecting them. If two pieces of wire of different material—for instance, one of copper and one of iron—are joined together and heated at the point of union, a small current of electricity will be generated. This is known as thermo-electricity, and the wires comprise a thermocouple. It is true that the current generated is very small. Wires of precious metals for high-temperature measurement, such as one wire of platinum and the other of 90 per cent platinum and 10 per cent rhodium, generate only 0·01 volt (10 millivolts) at a temperature of 2,000 deg. Fah. Wires of base metals, such as iron, copper, and nickel, for measuring moderate temperatures, generate several times the voltage of a platinum thermocouple, or about 50 millivolts at 2,000 deg. Fah. Experience seems to show that for measuring temperatures up to 200 deg. Fah. a thermocouple of bismuth and antimony is best.

Thermocouples of base metal are manufactured of diameters running from 0·01 in. up to 0·25 in. Platinum-rhodium thermocouples usually are furnished with wire of a diameter of 0·02 in. However, they have been made with wire less than 0·01 in. in diameter.

### Measuring Voltage Produced by a Thermocouple.

There are two distinct methods of measuring the voltage produced by a thermocouple—namely, the millivoltmeter method and the potentiometer method. The millivoltmeter directly reads the temperature across the scale, and is calibrated in actual degrees. It indicates the temperature from zero to a maximum scale range; it relies entirely on the voltage of the thermocouple for its operation, no outside source of current being necessary.

The advantage of the potentiometer method of measuring temperatures is in its extreme precision, and it is independent of resistance changes throughout the thermocouple circuit. It has the disadvantage as compared with the millivoltmeter method that it is not direct reading, and

that some outside source of current—a dry cell, for example—is necessary as a source of current to oppose the thermocouple, and this dry cell must be replaced from time to time.

The radiation type of pyrometer is used to measure temperatures from 2,800 deg. Fah. up. In this type, instead of placing the thermocouple in the furnace where the temperature would be so high as to destroy it, it is placed in the back of a tube in front of a mirror. The rays of heat from the furnace enter the tube and strike the mirror, and are brought to a focus on a thermocouple junction which attains a temperature of only 200 deg. or 300 deg. Fah. It is not recommended for service where a thermo-electric pyrometer with base metals or platinum thermocouples can be used.

### Pyrometers should be Re-standardised.

It is very essential, if accurate results are to be secured from pyrometers, that they be re-standardised at frequent intervals. If a thermocouple is installed in a furnace and allowed to run for six months without re-testing, sooner or later it will fail, and the user will find that the temperature measurements are away off. The frequency of standardising depends on the precision necessary in the work and the equipment available. Some plants make a point of checking their thermocouples once a week; if this is impossible it should be done at least once a month.

This checking can be very satisfactorily done by maintaining a standard platinum thermocouple used for checking secondary standards of base metals. An electric furnace should be used not less than 10 in. deep, so that a base-metal thermocouple can project at least 6 in. or 8 in. inside the furnace. The base-metal thermocouple can be tied to the standard thermocouple with asbestos strings, the junctions of the two thermocouples almost touching each other. The thermocouples should never be tested in their projecting pipe. A base-metal thermocouple can never be tested in a furnace with an insertion of less than 6 in., for the reason that the cross section of the thermocouple wires is large, and the outer end of the thermocouple wires in the cold air conducts the cold along the wires into the furnace, and will reduce the indication at the thermocouple junction on this account. The temperature of an electric furnace should be maintained constant for at least 15 minutes before a reading is taken, and tests should preferably be made at the working temperature of the thermocouple.

If the thermocouple under test reads low, and it has no adjustable resistance, it will have to be "junked." If it is furnished with a resistance for adjustment purposes, this adjustment can be easily made with a soldering iron.

### An Excellent Method of Testing Thermocouples.

The freezing point of pure salt affords an excellent method for testing thermocouples or of the complete pyrometer, consisting of the thermocouple, leads, and instrument. Insert a thermocouple in a small crucible containing pure salt (ordinary table salt is satisfactory) and heat to about 1,600 deg. Fah. Remove the crucible from the heat and allow it to cool off. At the freezing point of the salt, which will be indicated by the temperature remaining reasonably constant for four or five minutes, the pyrometer will read 800 deg. Cen., or 1,474 deg. Fah.

The melting point of a number of different metals is quite satisfactory for the checking purpose. The metals most generally used for this purpose and their melting points are as follows: Tin, 450 deg. Fah.; zinc, 787 deg. Fah.; silver, 1,761 deg. Fah.; and gold 1,945 deg. Fah.

The Bureau of Standards at Washington is in a good position to test pyrometers and thermocouples for manufacturers in the country, and it is a good plan to have a stanward platinum or base-metal thermocouple tested there. They can furnish the millivolt values for the thermocouples, and this can be retained as a primary standard to test the secondary thermocouple. The cost of such a test is usually about 10 dollars, and the expense is well warranted.

It would appear that the greatest development work in temperature-measuring instruments will be done with the perfection of optical pyrometers, resistance thermometers, and thermo-electric pyrometers. There is a field for a high-grade optical pyrometer that can be used by any number of operators who will all secure the same results from the instrument. However, the greatest future in pyrometry would seem to be along the line of automatic temperature control. Instruments have been developed for automatically maintaining the temperature constant within 10 deg. Fah.

## THE SPONTANEOUS FIRING OF COAL.*

By J. S. Haldane, M.D., F.R.S.

During the last four years, since the establishment of the Doncaster Coal Owners' Research Laboratory in 1913, 13 papers (of which 12 were by Mr. T. F. Winmill and Mr. J. Ivon Graham) on the conditions under which spontaneous fires in coal occur, have appeared in the "Transactions" of this Institution as reports to the Doncaster Coal Owners' Committee. Each of these papers deals in detail with some aspect of the central subject, and it is perhaps somewhat difficult to follow out their full bearing. It has therefore been suggested to the writer that a paper very shortly reviewing the general results so far reached might be of service to mining engineers.

For many years there has been no practical doubt that the spontaneous heating of coal is due to an oxidation process occurring under such conditions that the heat formed by the oxidation cannot escape as rapidly as it is liberated. A very valuable review of work on this subject was recently published by Prof. J. B. Porter, of McGill University, Montreal†. Very little was known, however, as to the nature of the oxidation process, the laws determining it, and the amount of heat produced when a given volume of oxygen combined with coal at the ordinary temperature of a mine.

The first experiments completed for the Doncaster Committee were on this latter point, and were carried out at Cambridge by Mr. Lamplough and Miss Hill by a delicate calorimetric method which had already been used at Cambridge in a different form for physiological work. These experiments showed that for a given consumption of oxygen less heat is produced than during ordinary combustion at a high temperature. Mr. Winmill found later that the heat actually produced had been somewhat overestimated, and that it is about 2·1 calories per litre of oxygen absorbed. This is scarcely half the heat produced when 1 litre of oxygen combines with coal during combustion at a high temperature. Nevertheless, Mr. Winmill was able to show that when a small sample of suitable coal dust placed at ordinary temperature on the laboratory table was supplied with sufficient oxygen, and at the same time prevented from losing any heat, it burst into flame within about 24 hours.

* Abstract of paper read before the Institution of Mining Engineers.

† "Weathering of Coal," 1915. Report to the Department of Mines, Canada; Government Printing Bureau, Ottawa.

One of the difficulties in obtaining accurate measurements arose from the fact, of which we were at first unaware, that coal takes up oxygen in two different ways. In the first place, it combines chemically with oxygen, evolving much heat in doing so. The oxygen so combined cannot be recovered from the coal by the vacuum pump. But coal also takes up oxygen in another way, apparently analogous to simple solution of gases in liquids, and without sensible evolution of heat. The whole of this oxygen can be recovered by pumping, as was quite recently shown in a paper by Mr. Graham. In the case of oxygen, nitrogen, and hydrogen, the amount of gas which goes into solution in the coal is far greater than the amount dissolved by an equal weight of water; but, just as in the case of water, the amount dissolved varies directly as the pressure of the gas, and thus follows Henry's law for the solution of gases in liquids. The extraordinary solubility of gases and liquids in coal and other solids has turned out to be a fact of very great scientific and practical interest, and Mr. Graham's experiments have thrown a flood of new light on the presence of firedamp and other gases in coal; but the writer must not do more at present than point out the sharp distinction between the solution or "absorption" of oxygen in coal and the true "chemical" combination which causes spontaneous fires.

The next point investigated was the manner in which the oxidation of freshly-powdered coal diminishes with time. At first the oxidation is very rapid, but within a few hours the rate diminishes greatly, and then becomes daily less and less, until after a few weeks the rate is so small that it can hardly be measured. It appears that it is some particular kind of material in the coal that is attacked at ordinary temperatures by the oxygen, and that only a limited quantity of this material is present. When it has all been oxidised the coal is incapable of any further spontaneous heating, unless its temperature is first artificially raised. There seem, however, to be different varieties of easily oxidisable material; for with rise of temperature not only is the rate of oxidation increased, but the total amount of oxygen entering into combination may also be greatly increased. This indicates that the greater part of the easily oxidisable substances are so constituted as not to be attacked by oxygen at a lower temperature, but begin to be oxidised when the temperature rises, and then accelerate the rate of heating.

*(To be continued.)*

# Queries and Replies.

We shall at all times be pleased to help our readers out of their difficulties to the best of our power, and invite them to make use of this column for that purpose.

W. H. C. (Bradford).—We quite agree; the subject is of immense importance. (See Correspondence Column.)

F. F. (Urmston).—We have written you direct.

C. Roggenkamp (Appingedam, Holland).—Yes, such regulations as you refer to have been in force in Great Britain for quite a long time. The police force in each town keeps a sharp eye on all delinquents, who can be summoned before a magistrate and fined. The most recent book on the subject is "Smoke Abatement," by H. Hamilton, reviewed on Page 478, and obtainable from Sherratt and Hughes, 34, Cross Street, Manchester.

J. D. T. (Reading).—Our advertising manager is writing you direct. Yes, we shall be pleased to help you in the direction named.

C. W. H. (Manchester).—We have referred your matter to our Publicity Department.

# Letters to the Editor.

The Editor will always be pleased to hear from readers who desire to express their opinions upon engineering and kindred subjects. Letters should be as brief as possible and be written upon one side of the paper only. The insertion of a letter in our columns does not necessarily mean that we endorse the opinions expressed therein.

### *RE* GROWING DEMAND FOR GAS FOR USE IN CONNECTION WITH MOTORS.

*To the Editor of "The Industrial Engineer."*

Sir,—In course of conversation with Alderman Kay, Chairman of the Manchester Corporation Gas Committee, I am given to understand that all sizes of connections are being used in conjunction with gas bags that are being supplied by various firms. Your readers will readily understand that it is highly desirable that a standard size of fit should be adopted, so that process of filling can be undertaken at various Corporations' works with the greatest possible despatch.

The Manchester Corporation, I understand, would like to see the 2 in. gas size adopted as standard. I suggest it would be interesting to invite your readers to discuss the matter through your valued columns, and I think that there would be very little difficulty in coming to a definite agreement throughout the country on the question at an early date, and thus save endless trouble, which is undoubtedly in store for owners of these gas-bags, if no such arrangement is introduced.

Another interesting suggestion, which it is desirable, to my mind, should be adopted, is that all quotations for the supply of gas for motor cars should be at "per 100 cubic feet."

It is interesting to be informed that the Manchester Corporation are prepared to test gas bags as to capacity, and to give certificates of such tests, and I think that if all Corporations who are interesting themselves in the "Gas for Motors" movement would adopt the same method and accept each others' certificates, and thereby be able to fill the gas bags which had been officially tested, without the necessity of the gas having to go through the meter, considerable time and inconvenience might be saved.—Yours, etc. (per pro. George Spencer, Moulton and Co. Ltd.), Leo. Swain

(Manager of the Solid Tyre Department).

Chairman of the Manchester, Liverpool, and District C.M.U.A.

### THE SAVING OF COAL.

*To the Editor of "The Industrial Engineer."*

Sir,—The following is the opening sentence of the Editorial in your issue of September 8th:—

"If there is one thing more than another which the war has accomplished in the domains of science and industry it is the awakening of the British people to the weaknesses which existed in many branches of our industry, and the necessity which thereby arose of exerting ourselves to remedy the defects."

Whilst fully agreeing with the spirit of this sentence, the latter leaves much to be desired in what may be termed the base line on which all our industries are built, *i.e.*, the better utilisation of our coals. I am well aware that you make reference to the importance of the work undertaken by the Fuel Research Board, and with which all thinking men will agree, but would respectfully suggest that between our general present methods of burning, or rather wasting, coal and the anticipated result of such research there is an intermediary step which can be taken, and one which will save many millions of tons of coal per year, liberate more men from our mines, remove the congestion on our railways, and give a purer atmosphere for all to breathe, besides assisting very largely the Research Board with their investigations.

Consider that one pound of coal only requires 15 lbs. of air for good practical combustion, and other things being equal to secure an overall steam plant efficiency of 76 per cent to 80 per cent, but in general practice we give more than double this weight of air per pound of coal, with the result that our plant efficiency is generally much nearer 60 per cent than 70 per cent. The cause of this excess air will be found chiefly through the boiler fires being too large in area for the outlets from the furnace flues, and which, in a 30 ft. by 7 ft. Lancashire boiler is four square feet of grate to one square foot of outlet, but in a boiler 30 ft. by 9 ft. the proportion is only 2¾ to 1, so that in the last-mentioned boiler, operated with equal draught, 2¾ square feet of grate does as much work as the four square feet in the smaller boiler.

I have carried out many trials with boilers, and find the best results when the ratio of grate to outlet is 2 to 1; if then this was made a standard for all boilers of the Lancashire type we should secure higher boiler duty per hour, and also practically the same evaporation per pound of coal burned in all sizes of boilers when using the same quality of fuel.

Below is given three Tables, A, B, and C:-

(A) Shows four Lancashire boilers working under present general existing conditions, and all subject to the same chimney draught.

(B) The same boilers with their grates shortened and made in proportion of two square feet of grate to one of outlet at the end of the furnace flues.

(C) Shows four Yorkshire boilers of the same diameter.

From a long experience with steam boilers, I am satisfied that by adopting more common-sense lines of working there will be no difficulty in effecting an actual saving of over £100 per boiler per year.

TABLE "A."

| Size of Boiler. | Length of Grate. | Grate Area in sq. ft. | Sq. feet of Grate to 1 sq. foot of Outlet from Furnace Flues. | Chimney Draught per min. in feet. | Speed of Air through Furnaces in feet per min. |
|---|---|---|---|---|---|
| ft. ft. in. | ft. in. | | | | |
| 30 × 9 0 | 6 0 | 33 | 4 | 1000 | 250 |
| 30 × 8 0 | 6 0 | 39 | 3½ | 1000 | 285 |
| 30 × 8 6 | 6 0 | 41 | 3 | 1000 | 333 |
| 30 × 9 0 | 6 0 | 45 | 2¾ | 1000 | 363 |
| TABLE "B." | | | | | |
| 30 × 7 0 | 3 0 | 16½ | 2 | 1000 | 500 |
| 30 × 8 0 | 3 9 | 24¼ | 2 | 1000 | 500 |
| 30 × 8 6 | 4 3 | 29½ | 2 | 1000 | 500 |
| 30 × 9 0 | 4 9 | 34¾ | 2 | 1000 | 500 |
| TABLE "C." | | | | | |
| 24 × 7 0 | 6 0 | 27 | 1·8 | 1000 | 555 |
| 24 × 8 0 | 6 0 | 32 | 1·8 | 1000 | 555 |
| 24 × 8 6 | 6 0 | 36 | 1·8 | 1000 | 555 |
| 24 × 9 0 | 6 0 | 38 | 1·8 | 1000 | 555 |

I am prepared to assist any steam user free of charge, on the following conditions:—

One-half of the money saving effected during the first six months after my suggestions are adopted he shall divide equally between the Red Cross branch and the Hospital for Wounded Soldiers in his locality.—Yours faithfully,

Milnthorpe, Wakefield. W. H. Casmey.

## EDITORIAL ASSISTANCE AND GOVERNMENT.

*To the Editor of "The Industrial Engineer."*

Sir,—Though we are far from desiring to see the British Government everywhere adopting or imitating the innovations of Allied or other Governments, we think the Premier might well take a leaf out of the book of Governor Whitman, of New York State. The Governor recently met in conference the Editors of the various technical journals in the State, desiring to get reliable evidence upon questions of mechanical production, transport, coal and timber conservation, the provision of machinists and toolmakers, and other vital factors essential to the successful prosecution of the war. As a result, the Governor has now a committee of five editors acting in an advisory capacity.

Perhaps no class in the community has its fingers more completely upon the pulse of British industries than the men who so worthily and efficiently edit our Technical Press, and we feel sure they might with advantage be called in to the State councils, where accurate information is, above all things, essential. At such a moment as this, when, to take only three important branches of public service, the Air, Agricultural, and Marine Departments, there is urgent need for the wisest and sanest counsels, as well as driving forces, we think nothing but good could come by the introduction of editorial assistance. —Yours, etc.,

Barimar Limited
(Scientific Welding Engineers).
C. W. Brett (Managing Director and General Manager).

# Reviews.

**Smoke Abatement.** By H. Hamilton. Manchester: Sherratt and Hughes, 34, Cross Street. 5s. net.

Considerable work has been accomplished during the past five years in collecting and collating evidence as to the detrimental effects of smoke. Figures are in existence which clearly demonstrate the costly depreciation of buildings, furnishings, and vegetation; and beyond this also we must reckon the great amount of heat lost when black smoke is emitted. Numberless inventions have been placed on the market, the object of which have been to consume the black smoke formed in combustion before it reaches the chimney. These smoke consumers have been traps for the unwary, and much good money has been lost in their flotation and purchase. In the present work the fanciful inventions introduced under the title of smoke consumers are left severely alone. The author has wisely concerned himself with stokers of a proved mechanical value, and of these he gives illustrations and descriptions. In earlier chapters the question of combustion is clearly dealt with; also, natural and artificial draught gas producers rightly find a place in this small but comprehensive book. We have always contended that in large towns the greatest culprits in the way of black smoke emission are the small householders. It is the many independent fires that go to provide the pall of black smoke which the naturally heavy, humid atmosphere of Lancashire holds down over its populous towns. The author devotes a chapter of small extent to this question of the domestic grate, but it would be absolutely impossible to exhaust this particular department of the subject, even in a book the size of the present one. There are alternatives. First, improved coal grates; secondly, gas or electric heating and cooking; and thirdly, the provision of steam for heating and cooking. We are too old a country to change the present conditions quickly. If we had to entirely rebuild, then central power stations, central heating stations, and probably improved electricity and gas supplies and devices would provide a solution. At the moment the question is difficult, and if the present work will assist in any measure the steps now being taken to solve the problem, then the author is more than justified. He has done his work quite well, and has provided a useful book.

**Registration and Publication of Directors' Names.** By Herbert W. Jordan. London: Jordan and Sons Ltd., 116 and 117, Chancery Lane, W.C. 2s. 6d. net.

This is practically a summary of the principal provisions of The Companies (Particulars as to Directors) Act, 1917. The necessary details required are given, and the whole provisions are considered, being accompanied by a running commentary that is interesting and illuminative. No doubt many readers will appreciate this little book.

**Some Modern Methods of Ventilation.** By R. Grierson. London: Constable and Co. Ltd., 10, Orange Street, Leicester Square, W.C. 8s. 6d. net.

It would be impossible in a book of the present size to fully exhaust the subject of ventilation and its closely kindred questions of heating or cooling and humidification. Much very excellent work has been done in the past by engineers who have devoted considerable time and money to research work in connection with ventilating plant. The difficulties experienced, especially in old buildings, are many, and anyone acquainted with the Manchester Royal Exchange will remember the several attempts at dealing with the atmosphere on the days of High 'Change. In the present work Captain Grierson does not attempt the impossible. He treats his subject in a concise manner, and although he omits a good deal, there is certainly much new and valuable matter in the book. Recent inventions in ventilating plant are described and illustrated. A great matter of importance in works is the increased temperatures due to running machinery, belts, etc. This is not touched upon by Captain Grierson. Cotton mill ventilation is not specifically mentioned; but this is a big subject, and one that will bear a book to itself. Particularly valuable are the chapters dealing with guarantees, tests, motor drives, and specifications.

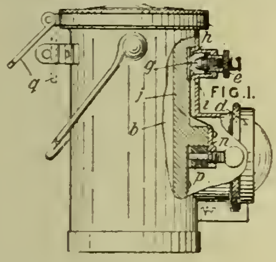
# Patent Applications.

*The following Abstracts of Specifications are brought up to the latest date possible, and are abstracted from the Illustrated Official Journal of Patents, which is published weekly.*

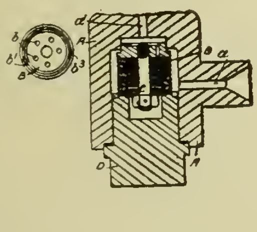
## ABSTRACTS OF SPECIFICATIONS.

### ELECTRIC INCANDESCENT LAMPS.

107,074.—O. OLDHAM, Denton, near Manchester.—June 22nd, 1916.—Battery lamps: holders for miners' lamps in which the circuit is independent of the casing. Terminal strips are bent from the top of the battery *b* over its side to engage contacts situated in grooves in the segmental insulating block *j*. A flame-tight switch comprises a non-removable screw *e* working in the casing and carrying an insulated contact *g* over two contacts *h*, *i* on the block. The lamp cap screws into a brass piece *n*, partly spaced from the block to leave room for a spring-pressed connector *p* abutting against the central contact of the cap. In the screw cover *c* of the casing is a rotatable ring attached to a hasp *q*, by means of which the cover can be padlocked or sealed with a leaden rivet. A screw-on lens ring *d* is provided.




Patent 107,074.



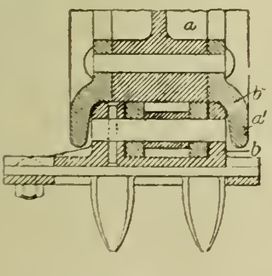
Patent 107,090.

### STRAINING OIL FUEL.

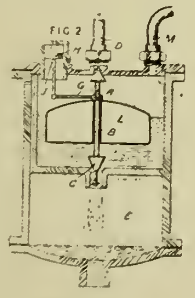
107,090.—VICKERS LTD., Vickers House, Broadway, Westminster, and J. MCKECHNIE and J. P. CLEAR, Naval Construction Works, Barrow-in-Furness, Lancashire.—July 8th, 1916.—In liquid-straining devices, especially for straining oil fuel for internal-combustion engines, and of the type comprising a pile of plates B secured together so as to have longitudinal passages *b* through the pile and fine passages between the plates so that solid particles cannot pass with the liquid through them into the pile, the straining-channels $b^3$ are formed by milling or knurling ribs $b^1$ on one face of the plates, and the ribs are adapted to contact with the adjacent plates. The pile is secured in a casing A provided with an inlet *a* and an outlet $a^1$, either by means of a plug D, as shown in Fig. 1, or by the bolt *c*, upon which the plates B are threaded, screwing into the casing.

### MOTOR-TRACTORS, ETC.

107,097.—W. E. MARTIN, Rock House, Scotgate, Stamford, Lincolnshire.—July 13th, 1916.—In motor tractors, ploughs, etc., which are driven by endless tracks, the guiding-wheels *a* for the tracks are provided with flanges $a^1$ forming grooves for the tracks. The flanges may be formed of separate pieces as shown. The centre portion of the groove is flat, the end portions being rounded where contact is made with the rounded edges $b^1$ of the outer links *b*.



Patent 107,097



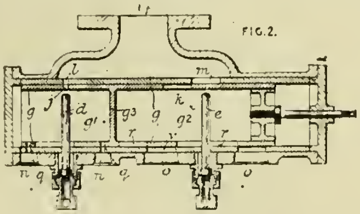

Patent 107,101.

### INTERNAL-COMBUSTION ENGINES.

107,101.—J. M. SANDERS, Lichfield Lodge, Keynsham, near Bristol.—July 18th, 1916.—For raising liquid fuel by the engine suction to the float chamber of a carburettor, the apparatus shown is used. It comprises a vessel with three valves A, C, H, rigidly connected to a rod B and controlling respectively the passage D to the engine suction pipe, the discharge orifice, and an air admission port J. A float L impinging upon an arm G closes the valve A and opens the valves C, H, allowing the fuel to escape to the vessel E whence it flows to the carburettor. When the upper chamber is empty, the weight of the float closes the valves C, H and opens the valve A; the partial vacuum in the induction pipe consequently causes fuel to flow from the pipe M.

### INTERNAL-COMBUSTION ENGINES.

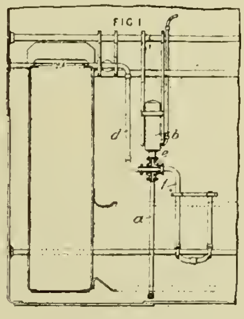
107,124.—J. W. KINCHIN, 73A, Westfield Road, Kings Heath, and W. TRANTER, 38, Church Road, Northfield, Birmingham.—September 15th, 1916.—The induction pipe may be placed in communication with either a petrol or a paraffin carburetting chamber by means of an adjustable sliding or rotatable ported tubular valve, the interior of which is divided to form the carburetting chambers. The valve *g* is divided by a partition $g^3$ into two chambers $g^1$, $g^2$ into which nozzles *d*, *e* for petrol and paraffin respectively project. Each chamber has air inlet ports *n*, *q*, *o*, *v*



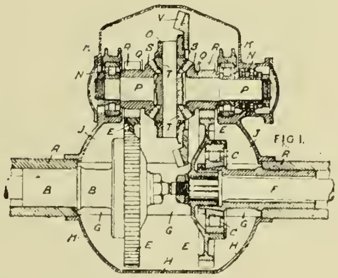

and mixture outlet ports *j*, *l*, *k*, *m*. The ports *q*, *r*, *j*, *k* are formed in a sleeve which may be adjustable independently of the valve *g*. In the position shown, the petrol carburettor is in action; by moving the valve *g* to the right, the petrol carburettor is put out of, and the paraffin carburettor brought into, action. The induction passage *f* is provided with a series of exhaust-heated tubes.

### STEAM GENERATORS.

107,143.—J. BRUNDRIT, 6, Oriel Chambers, Water Street, Liverpool.—October 16th, 1916.—The suction pipe *a* of an automatic pulsating water-circulator *b*, such as is described in Specification 26967/06, is fitted with an injector *e*, into which the feed-water is delivered through a pipe *d*. The injector delivery pipe *f* is extended downwards near the flues, as shown.




Patent 107,143



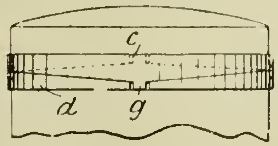

Patent 107,149.

### MOTOR VEHICLES.

107,149.—ALBION MOTOR CAR CO. and T. B. MURRAY, South Street, Scotstoun, Renfrewshire.—October 26th, 1916.—In a live rear axle of the kind in which there is a final train of reduction gearing, the differential gear comprises a single-piece central member O carrying planetary bevel-pinions T and a driving-wheel V and having stub axles P on which sleeves Q are mounted. The sleeves are provided with bevel-pinions S and spur gears R of the final reduction gear. The gears R mesh with gears E which are fixed on the axle parts F, and are concave to receive ball or roller bearings C, by which they are supported on sleeves B formed on or forced into the inner ends of the dead axle A. The casing consists of a ring forging G, of which the axle tubes A are extensions, and an annular casing J formed with a bearing for the propeller shaft. A casing H is secured beneath the forging G, a second casing K having bearings N for the shafts P being bolted to the casing J.

### PISTON PACKING.

107,180.—W. MARCH and A. MANN, 9, Lilyville Road, Fulham, and D. W. ROBERTSON, 259 Warwick Road, both in London.—January 30th, 1917.—In packing of the type described in Specification 15914/13, in which split rings are employed in pairs *c*, *d* having

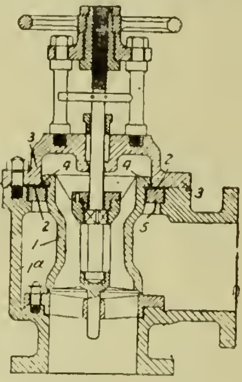


their surfaces in mutual contact inclined, one ring or each ring is formed with a projection *g* entering the slit in the other ring. The rings are split at their parts of minimum depth, and the depth of the projections is preferably equal to the minimum depth of the rings.

### VALVES.

107,153.—D. COCKBURN and D. MACNICOLL, of Cockburns Ltd., Cardonald, near Glasgow.—November 8th, 1916.—In a double-beat or balanced valve of the type fitted with a flexible seating ring or disc, the ring 2 is closely imprisoned all round so as, in the

event of fracture thereof, to prevent fragments of appreciable dimensions from being carried into the steam passage-way. In one form, the ring 2 is clamped between the valve casing 1a and its cover 3, and is imprisoned on one side by the cover 3 and the valve facing 4 and, on the other side, by a guarding 5 which fits

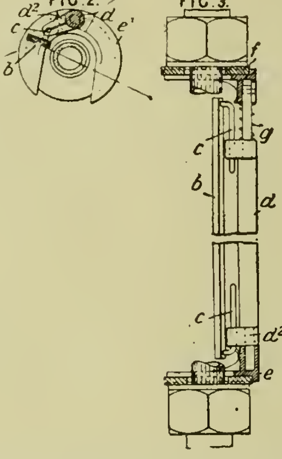


the valve 1 below the upper facing 4 with only a slight clearance. In a modification, the flexible ring is arranged as a facing on the valve below the seating 4, a ridge on the imprisoning ring 5 forming the valve seating. The valve is shown as operable by a rotary non-reciprocating nut mounted in a bridge member on the valve cover 3.

**INDICATING LIQUID LEVELS.**

108,026.—L. G. WALKER, "Martlesham," Egmont Road, Sutton.—July 19th, 1916.—Gauge glasses and the like.—To facilitate the reading of a gauge-glass or the like, the glass is illuminated, and a screen is arranged at the focus of the lens formed by the glass and its liquid contents, so that a bright line of light corresponding to the height of the liquid is produced upon the

FIG. 2. FIG. 3.



screen. The screen $b$ is hinged by pins $c$ engaging in holes in elips $d2$ upon a rod $d$ attached to the gauge. The rod engages in slots in plates $e$ adapted to slip over washers $f$ on the gland nuts. The plates are held in position by a spring $g$. The screen may be formed integral with the glass, or the light may be placed behind and the screen directly in front of the glass.

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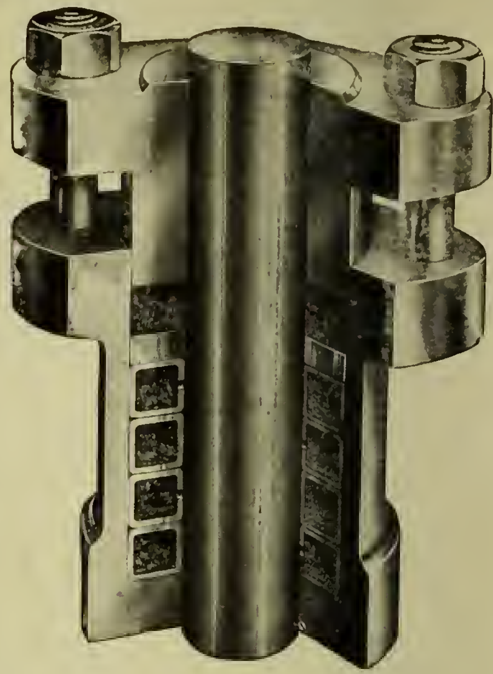

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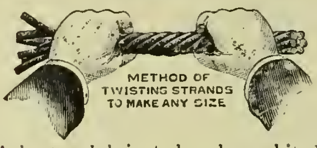


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